Proceedings
3rd National Organic Tree Fruit Research Symposium

June 6-8, 2005
Campbell's Resort, Chelan, Washington, USA

Hosted by:
Washington State University Center for Sustaining Agriculture and Natural Resources
Washington State University Tree Fruit Research and Extension Center
Washington Tree Fruit Research Commission
Wenatchee Valley College/IRIS
Washington Organic Tree Fruit Growers Association
Oregon State University Department of Horticulture

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PROGRAM

June 6	**All day orchard tour**
June 7	
830a	**Welcome** David Granatstein, Washington State University Meeting goals Overview of organic tree fruit trends
845a	**What will the future require for successful organic orchards?** Panel of 3 speakers on trends and issues that will influence the context for organic tree fruit research over the next 5-10 years. Moderator: Curt Rom, Univ. Arkansas
850-910	Megatrends & organic food: Clark Driftmier, Aurora Organic Dairy
910-915	Q&A
915-935	Outlook for organic tree fruit: Fred Kasak, Whole Foods buyer
935-940	Q&A
940-1000	Grower perspective: Harold Ostenson, George, WA
1000-1030	Discussion
1030-1045	Break
1045a	**Regional reports** Situation and developments in organic tree fruit by region. Moderator: Steve Ela, Ela Family Farm
1045-1105	Northeast: Ian Merwin, Cornell University
1105-1115	Discussion
11150-1135	South: Curt Rom, University of Arkansas
1135-1145	Discussion
1145	Lunch (provided in East/West Room)
100-120p	Midwest: Mark Whalon, Michigan State University
120-130	Discussion
130-150	California & Southwest: Sean Swezey, UC-Santa Cruz
150-200	Discussion
200-220	Pacific Northwest, British Columbia, Colorado: Kent Mullinix, Washington State University
220-230	Discussion
230-300	Trends in South America: Enrique Sanchez, INTA, Argentina
300-315	Discussion
315-330	Break

330-700p **Poster session**
Facilitator: Annie Chozinski, Oregon State University.
Three groups of audience will rotate among 3 groups of posters and a discussion session. Each poster presenter gives a 2-3 minute synopsis, followed by discussion. The Research Needs discussion will be in Ballroom 2. Snacks at 4:15pm and a no-host bar at 5:45pm in the Foyer.

Time	Pest Mgt & Regional Initiatives 1: Poster Cluster A	Pest Mgt & Regional Initiatives 2: Poster Cluster B	Soil, Nutrients, & Crop Physiology: Poster Cluster C	Discussion: Research needs
3:30-4:15	Group 1	Group 2	Group 3	
4:15-5:00	Group 2	Group 3	*	Group 1
5:00-5:45	Group 3	*	Group 1	Group 2
5:45-6:30	*	Group 1	Group 2	Group 3
6:30	Visiting time for individual posters.			

* Presenters from this cluster are free to choose a poster cluster to visit.

700p Dinner (on your own)
Cluster Group facilitators and reporters meet at Chelan Fire Hall

June 8
830a **Creating and funding a research agenda**
Moderator: Kent Mullinix, Washington State University

840-915 Systems research: What does it mean? What does it take?
Steve Temple, UC Davis
915-945 Discussion

945-1000 Break

1000 Research priorities: Reports from cluster groups
Cluster Group A: Curt Rom, Jay Brunner
Cluster Group B: Mark Whalon, Annie Chozinski
Cluster Group C: Ian Merwin, Loys Hawkins
1030 Discussion

1045 Funding
Steve Ela, Organic Farming Research Foundation
Jim Kotcon, USDA-CSREES Organic Program
Sandy Halstead, Western SARE (Sustainable Ag Research & Education) Administrative Council
Bonnie Rice, WA Sustainable Food & Farming Network
Jim McFerson, Washington Tree Fruit Research Commission
Chris Feise, WSU Center for Sustaining Ag & Natural Resources
1115 Discussion
1145 Next steps – future meeting, work groups

1200 Lunch (provided in East/West Room)

100p **What's next?** *continued*
Continuing the discussion and building the research agenda
Next steps: future meetings, ongoing work groups

300 Adjourn

Organic Tree Fruit Research Needs for Washington State

David Granatstein, WSU Center for Sustaining Agriculture and Natural Resources, Wenatchee, WA
September 2003

Meetings were held in Wenatchee and Wapato during November and December 2002 with researchers and organic orchardists to determine priorities for organic tree fruit research in the state. The meetings were convened by Washington State University, Washington Tree Fruit Research Commission, and USDA-ARS. An initial list of needs was developed and mailed to all organic orchardists in the state, requesting their input on prioritization of the needs. Only about 20 responses were received. The narrative below reflects input from both the meetings and the survey responses. Table 1 summarizes the survey responses, where rankings of 1 (low) to 5 (high) were used, and the rank number was multiplied by the number of respondents to create a score for the need (using only rankings 4 and 5).

Findings

Organic tree fruit producers have research needs that may be unique to their production system as well as needs that apply to all growers in the state.

General. Growers would like more systems studies for organic orchards that would help reduce the need for external inputs and maximize the ability to produce fruit quality in line with consumer desires. Deciding what organic standard (e.g., U.S. vs. Europe) to use as the basis for research is an unresolved question. Growers supported the idea of an extension person who would help pull together and synthesize information for organic growers and generate new information through surveys and other means.

Horticulture. Crop load management (blossom thinning), weed control, and soil management are the three priority areas of need for horticulture. Current work on thinning is providing viable options, but alternatives to sulfur and post-bloom options are needed. Weed control methods that reduce cost and impact on the soil are needed, such as the current mulching and cover crop work, and evaluation of new weed control materials (e.g., acetic acid) is a high priority. More work is needed to develop reliable guides for using various organic fertilizers in orchards, especially for obtaining good growth of young trees and for maximizing the value from the relatively expensive organic nutrient sources. Vertebrate pest control, especially for rodents, is a weak link to exploiting novel orchard floor management strategies. Other horticultural issues include water management, breeding trees for organic systems, Gala stem end splitting, and the effect of organic practices on fruit quality.

Entomology. Codling moth remains a key pest for apples and pears. Current tools such as pheromones need to be retained, new tools such as virus need to be developed, and studies of the integration of the various controls are needed to optimize the system. Cherry fruit fly requires new control techniques, and research and education will be needed to properly use the new spinosad formulation for organic growers to avoid resistance problems. There are no good controls for true bugs. Non-sulfur controls for pear rust mite are needed. Other pests of concern include thrips, black cherry aphid, and pear slug. Growers would like increased research on conserving and enhancing beneficial insects in orchards that can exert meaningful biological control. Research is needed on new products, including those reformulated for organic production, to guarantee efficacy.

Pathology. Alternative controls to sulfur and copper are needed. Breeding is the best approach for controlling scab, mildew, fire blight, and bacterial canker. Growers need alternatives to fumigation for replant disease, and research is ongoing. Research on new products and techniques, such as compost tea and systemic acquired resistance, would be useful.

Postharvest. Key issues include alternatives to chlorine, control of storage disorders (scald, cherry decay), new treatments for export phytosanitary requirements, potential benefits from plant growth regulators (e.g., ReTain), and DPA contamination. More needs to be known about how organic fruit quality is affected by storage and whether pre-harvest practices in organic orchards can help manage storage diseases. There may be a need for new packaging options for organic fruit.

Table 1. Organic tree fruit research priorities based on rankings by growers.

Research Need	Weighted ranking values		
	5	4	Totals
General			
1. Systems Studies	40	4	44
2. Organic Extension Agent	15	8	23
3. Survey of organic practices	0	24	24
Hort—Soils			
1. Fertility mgt. in organic soils	25	24	49
2. Soil quality	5	16	21
3. Evaluate fertility products	0	8	8
4. Site-specific nutrient mgt.	5	16	21
5. N on young trees	0	8	8
6. Soil effects on fruit quality	25	12	37
7. How to measure soil biology	20	16	36
Hort—Weeds			
1. Alternatives to tillage	30	24	54
2. Use of ground covers and mulches	30	24	54
3. New products (e.g., vinegar)	35	32	67
Hort—Crop Load Mgt.			
1. Timing, rates on chem. thinners	10	16	26
2. Need non-sulfur thinners	15	24	39
3. Post-bloom thinning options	30	12	42
4. Integrate bloom mgt. with N mgt. to reduce biennial bearing	20	28	48
Hort—Other			
1. Water mgt. link with fruit quality	0	36	36
2. Influence of org. practices on fruit quality	25	16	41
3. Breeding—sp. for organic conditions	10	8	18
4. Vertebrate pest control	35	16	51
5. Reducing Gala stem end splitting	20	16	36

Research Need	Weighted ranking values		
	5	4	Totals
Entomology			
1. Codling moth—new controls	60	16	76
2. Areawide management in organic	0	0	0
3. Integrate all possible controls	25	20	45
4. More policing of unsprayed trees	10	8	18
5. Cherry fruit fly controls	30	20	50
6. Controls for true bugs (lygus, stink, campy)	5	12	17
7. Spinosad use	5	20	25
8. Thrips—control tools on apple and cherry	5	8	13
9. Black cherry aphid—need control options	5	8	13
10. Pear rust mite—need controls other than S	5	12	17
11. Evaluate products reformulated for organic	15	32	47
12. Enhancing beneficial insects	20	40	60
Pathology			
1. Replant disease—controls, genetics	25	20	45
2. Mildew—breed resistant varieties	15	12	27
3. Fire blight—breed resistant varieties	0	8	8
4. Bacterial canker	5	12	17
5. Alternatives to sulfur as a fungicide	15	16	31
6. Alternatives to copper as a fungicide	10	20	30
7. Efficacy of novel controls	15	20	35
8. How to utilize Systemic Acquired Resistance	5	28	33
Postharvest			
1. Chlorine—alternatives	20	16	36
2. Storage disorders—scale (predicting, use of ozone)	5	52	57
3. Phytosanitary options for export—temperature, RF	25	16	41
4. Organic options for pre-harvest ctrl. storage dis.	40	36	76
5. Cherry decay with longer storage	5	16	21
6. Fruit quality differences with organic fruit	15	16	31
7. Packing containers suitable for organic	0	20	20
8. DPA residues on organic fruit	5	0	5
9. Increase luster on Red Delicious	5	16	21
10. Use of plant growth regulators—e.g., ReTain	5	20	25

Rankings based on responses from 21 growers.

Trends of Organic Tree Fruit Production in Washington State

D. Granatstein, E. Kirby and C. Feise
Center for Sustaining Agriculture and Natural Resources
Washington State University, Wenatchee, WA

Organic certification of tree fruit in Washington State began in 1988 with the establishment of the Organic Food Program (OFP) in the Washington State Dept. of Agriculture. We have been compiling statistical data on the organic sector in the state using their data (Granatstein and Dauer, 2000; Granatstein and Kirby, 2002). Our goal is to produce an annual update of organic tree fruit acreage in the state to provide growers and the industry with current information on these crops to aid in their business decisions. Modest changes in production acres can have significant impacts on the marketplace, and thus current information is essential. Also, our reporting provides a level of detail not available elsewhere, and knowing the trend by variety, for example, Red Delicious versus Gala, is critical, while data for generic 'organic apples' will be minimally useful for working in the fresh pack arena.

The acreages reported below are estimates; all available statistical sources have accuracy challenges. The numbers are current as of January 2005 based on data from the Washington State Dept. of Agriculture, Dovex Fruit Co. (certified by Quality Assurance International) and Oregon Tilth Certification Organization. We wish to thank the individuals who have cooperated on this project including Miles McEvoy and Les Eklund (WSDA), Chris Schreiner and Peter Gonzalves (OTCO), and Noel Adkins and Lisa Crawford (Dovex). Funding for this report was provided by the Organic Cropping for the Northwest special grant from USDA-CSREES.

Table 1. Estimated organic apple acreage in WA state (ac) by year.

	1998	1999	2000	2001	2002	2003	2004
Certified	**1809**	**2334**	**4228**	**6540**	**7054**	**7003**	**7049**
Transitional	2308	3590	3997	3415	590	719	844
Total	4117	5924	8225	9955	7644	7722	7893

Table 2. Estimated organic pear acreage in WA state (ac) by year.

	1998	1999	2000	2001	2002	2003	2004
Certified	**449**	**456**	**619**	**1308**	**1771**	**1466**	**1509**
Transitional	169	624	1040	642	192	80	201
Total	618	1080	1659	1950	1963	1546	1710

Table 3. Estimated organic cherry acreage in WA state (ac) by year.

	1998	1999	2000	2001	2002	2003	2004
Certified	**95**	**107**	**193**	**303**	**507**	**513**	**581**
Transitional	90	107	165	280	69	58	158
Total	185	214	358	583	685	571	739

Table 4. Certified apple variety acreage by year.*

	2000 (ac)			2001(ac)			2002 (ac)			2003 (ac)			2004 (ac)		
Variety	**Cert**	Trans	Total	**Cert**	Trans	Total	**Cert**	Trans	Total	**Cert**	Trans	Total	**Cert**	Trans	Total
Gala	**596**	577	1173	**1040**	440	1481	**1434**	76	1510	**1429**	107	1536	**1341**	167	1508
Red Delicious	**1512**	984	2496	**1872**	864	2736	**1251**	168	1419	**1222**	161	1383	**985**	113	1097
Fuji	**425**	606	1031	**807**	408	1215	**1052**	76	1128	**1072**	129	1201	**1151**	111	1261
Granny Smith	**452**	625	1077	**1053**	651	1704	**828**	64	892	**827**	76	903	**819**	144	963
Golden Types	**603**	304	907	**971**	142	1113	**861**	14	875	**821**	61	882	**797**	104	901
Braeburn	**186**	165	351	**258**	177	435	**485**	33	518	**497**	18	515	**494**	51	544
Pink Lady	**83**	196	279	**128**	532	660	**470**	116	586	**467**	122	589	**591**	60	651
Other	**209**	71	280	**260**	51	310	**331**	10	341	**323**	10	333	**517**	23	540
Cameo	**93**	350	443	**151**	146	297	**191**	21	212	**188**	21	209	**191**	21	212
Honey Crisp							**151**	11	162	**157**	18	175	**165**	50	215
Total	**4159**	3878	8037	**6540**	3411	9951	**7054**	589	7643	**7003**	723	7726	**7049**	844	7894

**Values through 2002 inc. WSDA data only; 2003 values include WSDA and QAI (Dovex) data.
2004 values also include OTCO (0 acres) data.*

Table 5. Estimated Washington organic pear acreage by variety and year.

	2002 (ac)			2003 (ac)	
Variety	**Cert**	Trans	Total	**Cert**	Trans
Anjou	**755**	62	817	**529**	41
Bartlett	**431**	67	498	**455**	11
Bosc	**370**	23	393	**284**	6
Asian	**60**	10	70	**47**	5
Red Anjou	**49**	8	57	**41**	10
Concorde	**44**	7	51	**48**	
Red Bartlett	**39**	3	42	**30**	8
Other	**22**	13	35	**32**	
Total	**1771**	192	1963	**1466**	80

*Values through 2002 inc. WSDA data only; 2003 values include WSDA and QAI (Dovex) data.
2004 values also include OTCO (0 acres) data.*

Table 6. Estimated Washington organic soft fruit acreage, 2002-2004.

	2002 (ac)			2003 (ac)			2004 (ac)		
Crop	**Cert**	Trans	Total	**Cert**	Trans	Total	**Cert**	Trans	Total
Cherry	**507**	69	576	**513**	58	571	581	158	739
Peach	**187**	0	187	**175**		175	**148**	9	157
Apricot	**77**	12	89	**78**	12	90	**96**		96
Nectarines	**66**	3	69	**57**		57	**50**	8	58
Plums/Prunes	**61**	3	64	**63**		63	**35**		35
Totals	**898**	87	985	**886**	70	956	**910**	175	1085

*Values through 2002 inc. WSDA data only; 2003 values include WSDA and QAI (Dovex) data.
2004 values also include OTCO (0 acres) data.*

Table 7. Changes in Washington State certified organic tree fruit acreage, 1988-2004.

	Apples			Pears			Soft fruit		
Year	Apples (ac)	Annual acreage change	Annual % change	Pears (ac)	Annual acreage change	Annual % change	Soft fruit (ac)	Annual acreage change	Annual % change
1988	109			29			36		
1989	365	256	235	31	2	7	85	49	136
1990	1632	1267	347	164	133	429	269	184	216
1991	1253	-379	-23	344	180	110	197	-72	-27
1992	930	-323	-26	336	-8	-2	173	-24	-12
1993	807	-123	-13	323	-13	-4	131	-42	-24
1994	849	42	5	339	16	5	161	30	23
1995	861	12	1	320	-19	-6	149	-12	-7
1996	1115	254	30	361	41	13	163	14	9
1997	1634	519	47	411	50	14	194	31	19
1998	1809	175	11	449	38	9	208	14	7
1999	2334	525	29	456	7	2	216	8	4
2000	4228	1894	81	619	163	36	385	169	78
2001	6540	2312	55	1308	689	111	588	203	53
2002	7054	514	8	1778	470	36	899	311	53
2003	7003	-51	-1	1466	-312	-18	884	-15	-2
2004	7049	46	0.7	1509	43	2.9	910	26	2.9

Values through 2002 inc. WSDA data only; 2003 values include WSDA and QAI (Dovex) data.
2004 values also include OTCO (0 acres) data.

References

Granatstein, D. and E. Kirby. 2002. Current trends in organic tree fruit production. Report No. 4, Center for Sustaining Agriculture and Natural Resources, Washington State University, Wenatchee, WA. 24 pp.

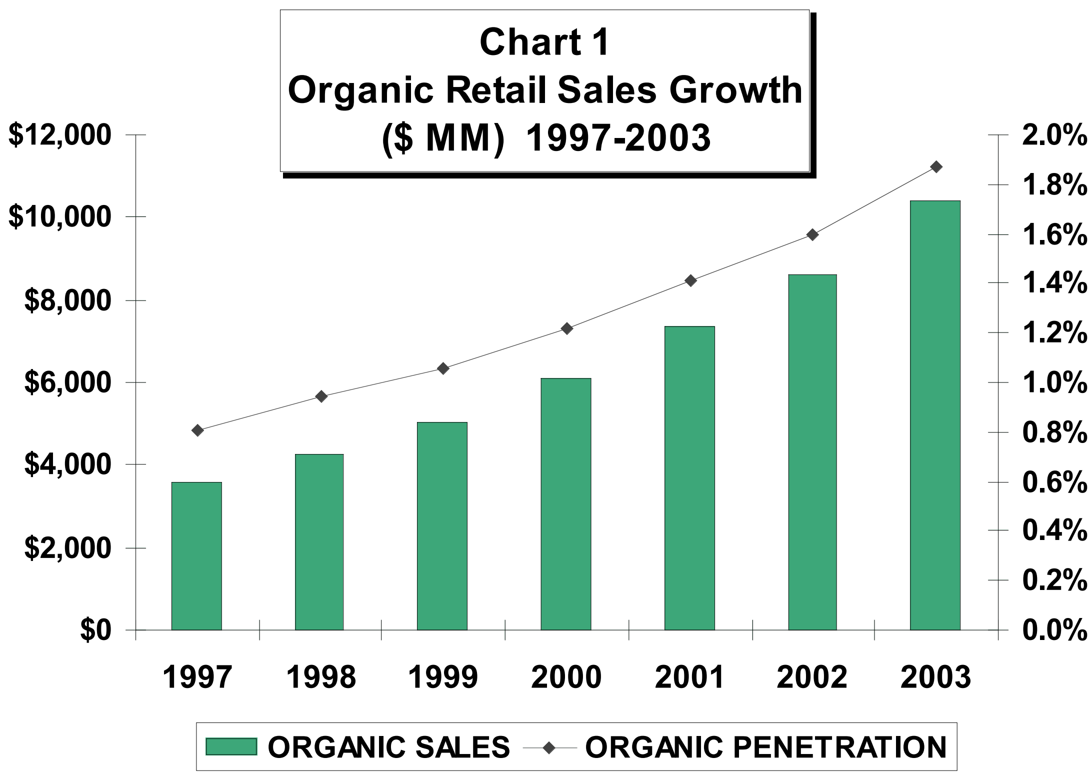
Granatstein, D. and P. Dauer. 2000. Trends in organic tree fruit production in Washington State. Report No. 1, Center for Sustaining Agriculture and Natural Resources, Washington State University, Wenatchee, WA. 22 pp.

Organic Market Trends and Research – A Marketer's Perspective

Clark Driftmier

I. Organic Industry Trends and Statistics
   1. <u>Current size and growth trends for organic industry</u>.

As most informed observers are aware, the organic industry comprises only a small portion of the overall grocery products industry—about 2%—but is growing much faster than the overall industry, with an annual growth rate of 20%. Organic products totaled over $10 billion in sales as of 2003, as shown in Chart 1 below, and by Dec. 2004 the estimate is approx. $12 billion.



There are several major reasons for the dynamic growth of the organic industry, including the following:

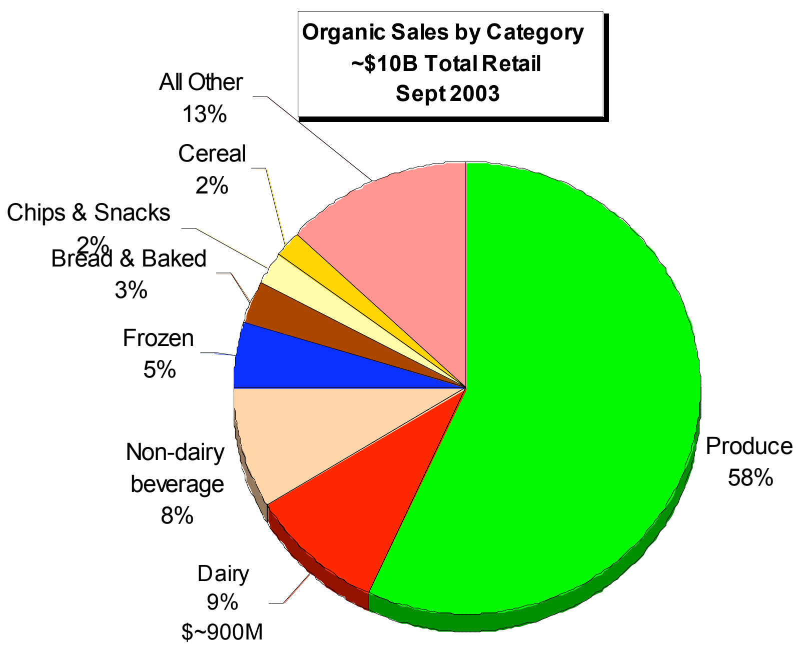
a) Increased consumer interest in health, nutrition and personal safety, along with increased concerns about possible "bad stuff" in food such as artificial hormones, antibiotics and pesticide residues.
b) Development of natural foods retailers, and greater presence of organic products in retail venues such as Grocery and Mass/Club/Drug.
c) "Mainstreaming" of organic products among consumers in terms of taste, packaging, convenience and positioning. Organic products have begun to move from the fringe of American consumption toward the center (or at least a modest start along that path).

d) Increasing availability of organic ingredients, in terms of both quantity and variety.
e) Declining cost of organic production.
f) Implementation of organic standards, including the USDA's national Organic Program, which lends credibility to organic products.
g) Investments from the financial community.

As the industry continues to develop, most observers conclude in general that the forces of growth will continue and that the industry will proceed on its rapid developmental path. This "rising tide" for the organic industry creates a favorable climate for organic industry stakeholders in the agricultural, distribution and retailing segments of the industry.

2. Composition of Organic Sales by Category. In 2003, organic sales were dominated by a few categories, with produce by far in the lead with well over half of all industry sales, as shown in Chart 2. This dominance by produce is consistent with previous data and reflects the greater distribution penetration of this category, its maturity and longevity in the market, as well as a perception by consumers that less-processed foods such as produce are more consistent with the overall proposition of organic. Another key reason for the dominance of produce is its frequent consumption by children and the concern among parents about their kids' intake of pesticides from this frequently consumed category.

Chart 2



Source: IRI; SPINS; 2003

3. Growth of Key Organic Categories. Within the overall "good news" of growth in organic products, certain categories are benefiting much more than others from the favorable trends. Several categories have become significantly larger and are experiencing more robust growth throughout the different channels of distribution. In general, the highest growth rates and the largest segment sizes have occurred in perishable products, refrigerated products, products with high regular consumption, and those products demonstrating a stronger link with health, nutrition and wellness, including:

a) Produce (as profiled above).
b) Non-dairy beverage.
c) Dairy.

Each of these categories has a series of properties which make it large, rapidly growing, and of significant interest to consumers, as outlined in Chart 3 below.

Chart 3
Key Categories Driving Organic Growth.

Rank	Category	Size	Growth	Issues
#1	Produce	$5.8 billion	+ 25%	• Very high, regular consumption. • High consumption by kids. • Well-publicized pesticide issues.
#2	Dairy	$950 million	+ 27%	• Very high, regular consumption. • High consumption by kids and developing pre-teens. • News about artificial growth hormones and antibiotics in conventional milk. • Concern about health issues such as early puberty, hormonal imbalance, endocrine disruption and other problems.
#3	Non-Dairy Beverage	$800 million	+ 50%	• Lactose intolerance in women and certain ethnic groups. • Beneficial news about isoflavones and beneficial reports about breast cancer. • Health benefits in soy for heart conditions, esp. older men.

Source: IRI; SPINS; Hartman Group 2003

4. The Importance of Organic for Grocery Industry Growth. Even though organic sales are a small portion of overall sales in the grocery industry—about 2%—the growth of organic accounts for about 25% of the GROWTH of the grocery industry, as shown in Chart 4 below. This growth, in no small part, accounts for the interest retailers have in building sales of their organic categories.

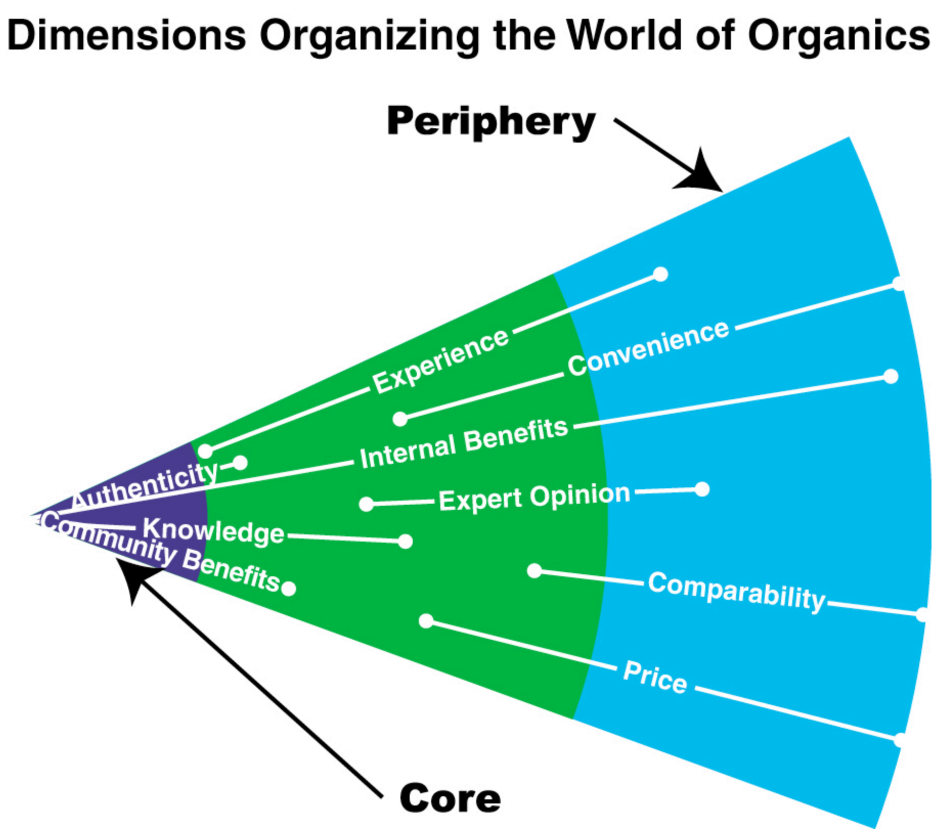
Chart 4
Sales and Growth – Organic vs. Other Grocery

	Sales ($ MM)	% of sales	Growth ($ MM)	% of growth
Organic	$10,000	2	$2,000	25
Other grocery	$525,000	98	$6,025	75
Total grocery	$535,000	100	$8,025	100

Source: IRI; SPINS; 2003

5. <u>Consumer Motivators for Organic Purchase.</u> There is an interesting dynamic in consumer perceptions and motivations relative to organic. The Hartman Group has segmented organic consumers relative to the intensity of their dedication to organic. As shown in Chart 5 below, the “left” end comprises the core organic consumers who value organic quite highly and are dedicated organic shoppers. These consumers are motivated principally by Authenticity, Knowledge (of organic, health and environmental issues) and Community values. Going out to the “right” end of the chart, peripheral consumers are motivated more by Price, Convenience and Comparability. This analysis supports much of the current emphasis of organic manufacturers and retailers, which is to broaden organic consumption by appealing to a larger group of more peripheral consumers who are motivated more by price, availability and convenience.

Chart 5

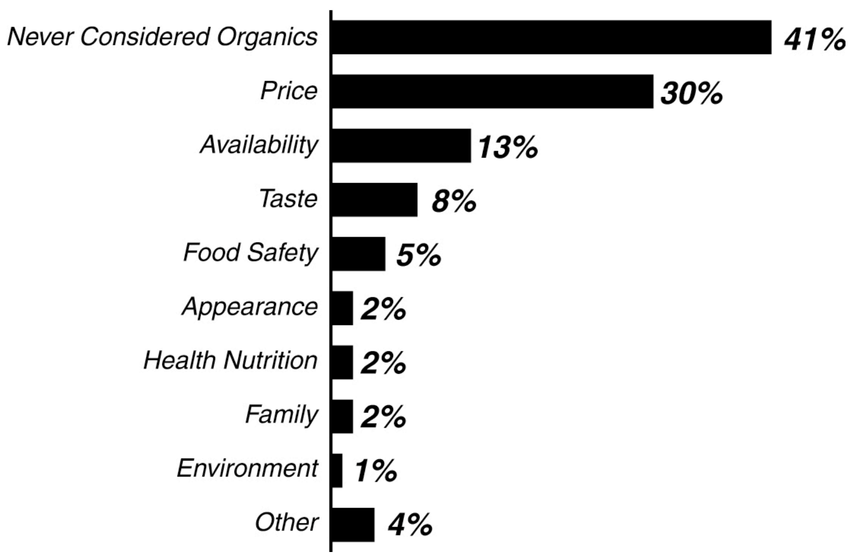


Source: The Hartman Group, 2001

6. Price as a Purchase Barrier. Building on the importance of price outlined above, there is another research project from the Hartman Group that identifies price as the 2nd most important barrier preventing organic purchase, as shown in Chart 6 below. Price ranks after "Never Considered Organics" which is an issue of awareness and understanding. This research backs up substantial qualitative research in which price consistently emerges as the #1 or #2 reason preventing purchase. Comments along the lines of "Well, I like organic, but it's just too expensive" are heard in almost every qualitative study of consumers. For organic companies, the opportunity to address the barrier of price is the opportunity to change one of the fundamental inhibitors of organic purchases.

Chart 6

Top Barriers to Organic Food and Beverage Purchases - Total Population



Source: The Hartman Group 2001

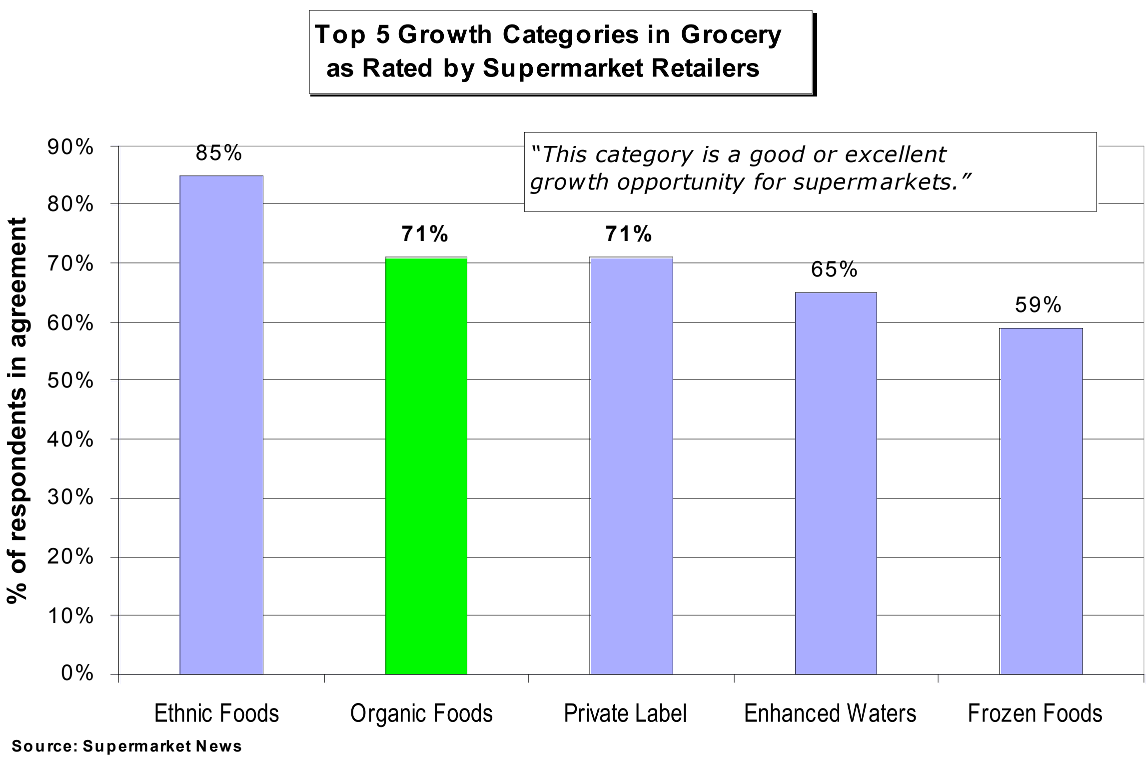
II. Retailer Insights (Supermarkets, Natural Foods, Club, etc.)

1. Retail Grocery. The retail grocery (i.e., supermarket) channel accounts for over half of all sales of organic products. With the increase of focus on organic in Grocery, there is a general increase in the percent of organic sales in this channel. Among organic categories, produce is by far the best developed organic category in grocery. Organic produce has almost 100% distribution in the channel and can be found in nearly all of the 35,000 supermarkets in the country.

As organic foods have grown in importance in Grocery, retailers have increased their allotment of shelf space to organic products. In addition, several retailers have switched their display of organic away from natural food sets toward fuller integration with conventional foods of the same category. Another commitment by retailers to organic has been the development of private label (or "store brand") organic products marketed under the retailer's own brand.

A testament to the importance of organic products to the growth of supermarkets can be found in a recent survey conducted by Supermarket News ("SN"), summarized in Chart 7 below. SN surveyed several hundred buyers and merchandisers, asking them which categories represented the best growth prospects for their stores. Organic was listed by 71% of the buyers as a good growth prospect and was the #2 ranked category, trailing only Ethnic Foods.

Chart 7



2. Natural Foods. The Natural Foods channel might be termed the "ancestral" home of organic products. In this channel organics were first marketed broadly to consumers during the 1970s and 1980s. For the Natural channel, the biggest change over the past few years has been the channel's increasing size, scale and more mainstream selling format. No longer are natural food stores the small, dark corner co-op with cramped aisles dominated by bulk bins. The natural food store of today is 5-10 times larger than previously (50-60,000 sq ft vs 5-6,000 sq ft), well-lit, expertly merchandised and managed by grocery professionals. The staff has all of the skills of their Grocery counterparts and then some—especially a much greater knowledge about the products, a result of the significantly more extensive training programs instituted by Natural retailers.

The modern natural stores appeal to a much broader and more mainstream consumer base than previously. These stores bring in upscale, mainstream consumers drawn as much by the gourmet or "Foodie" aspect of the stores as by their focus on organic products. Price is a significant barrier to the further mainstreaming of Natural retailers, and while efforts have been made to appeal to less affluent consumer segments, the Natural channel remains the food "hunting ground" of affluent, urban professionals.

3. Mass/Club. The Mass/Club channel, featuring retailers such as Costco, Sam's and BJ's, has seen a general increase in organic sales from a small base. One of the key features of organic sales in Mass/Club is its intermittent, "In and Out" nature, part of the merchandising strategy of the retailers. In general, pallets of organic product are intensively featured at "hot" prices for a period of up to six months, then are "cycled' out of distribution and replaced by other products, sometimes organic and sometimes not. For Mass/Club retailers, like the newer Natural stores, being organic is a way to express being gourmet as well as a statement about product purity and absence of pesticides.

The four leading categories of organic in Mass/Club are produce, dairy (esp. milk, yogurt and cheese), non-dairy beverage and dry grocery (such as olive oil and pasta sauce). Individual regions and geographies often feature organic products of a more local interest. One feature of Mass/Club that works in favor of organic sales is the low margin and low prices for the organic products. One can find genuinely good deals and low prices on organic products in Mass/Club, which addresses the key barrier of price and helps to bring more consumers into the organic franchise.

4. Food Service/Institutional. The Food Service and Institutional channel, though of tremendous importance to food sales overall, is significantly underdeveloped relative to organic products and their sales to consumers. True, there are a few organic products found in selected restaurants, college cafeterias and the like, but in general the penetration of organic in Food Service and Institutional is only a fraction of its penetration in other sales channels. That being said, Food Service providers such as Sysco know that they need to keep abreast of consumer purchase patterns and changes. As consumers bring their greater interest in organic to restaurants and food service venues, these providers will be certain to increase their offering of organic products to meet the needs of their customers. As of this writing, however, the initiatives in organic in this channel are relatively small.

III. Convergence of Factors in Organic vs. Conventional Agriculture.

One of the most interesting aspects of the evolution of both conventional and organic agriculture is the "convergence" or bringing together of many features of these two systems. This convergence is a change from much of the thinking during the seminal development of organic agriculture, when there was (and to a certain extent, still is) a strong "oppositional" philosophy that pitted organic agriculture against its conventional counterpart, including sentiments such as the following:

a) Something's wrong in conventional ag., and organic is here to fix it.
b) Conventional ag. = big industrial ag. = "bad," whereas organic ag. = small family farm ag. = "good."
c) Conventional ag. depletes the soil, whereas organic ag. builds the soil.
d) Conventional ag. poisons the land with chemicals, whereas organic ag. nourishes and replenishes the land.
e) Organic ag. is sustainable, but conventional ag. is not.
f) Organic farmers care about people and the planet, whereas conventional farmers (esp. larger entities) care mostly about profits.

g) In "Star Wars" argot, as cleverly portrayed in the recent spoof "Store Wars" put out by OTA, conventional ag. is the "Evil Empire," while organic is the "Noble Rebellion."

These statements fall into the category of stereotypic hyperbole, and like many such statements they contain elements of truth interwoven with large doses of hokum. There are, indeed, many unsustainable practices in conventional agriculture, and organic ag. does indeed focus intently on the health and fertility of soil. The reality, however, is much more complex than the banner wavers of either persuasion would like to admit, and the different systems of ag. co-exist in relationships that are quite symbiotic in many respects.

<u>Conventional Ag. is Becoming More "Organic"</u>

a) There is increasing realization across the spectrum of ag. that resources are finite, that fertility is fragile and limited, and that the goodness of the earth must be carefully husbanded, cultivated and renewed in order for ag. to thrive over the long term.
b) In general, farmers are reducing the use of pesticides of all types (if not their elimination), with more careful attention to limited application of these chemicals at precisely the correct time for maximum efficacy. This reduction is driven by several factors, including:
    - economic (saving money on expensive chemicals),
    - environmental (preventing further chemical pollution),
    - health (farmworker safety and concerns about possible ill effects).
c) Many non-organic farmers are changing their ag. systems to more sustainable methods. This is not a new trend; one has only to read about the conservation practices of the 1930s to surmount the problems of the Dust Bowl days. But in recent years, a more focused effort has been undertaken to make agricultural practices more sustainable.
d) Across the board, there is more focus on "chain of custody" issues and audit-ability of ag. systems. From livestock to tree fruits to corn, both consumers and components of the ag. industry want to know what the crop is, who grew it, where it came from, and how it was grown.
e) There is increasing focus on creating value-added vs. commodity ag. systems. Again, this is not a new trend, as attested by the purveyors of branded commodities such as Walla Walla or Vidalia brand onions. But the trend towards value-added food crops is accelerating, with initiatives in every sector, supported by government agencies up to the USDA Secretary calling for more value-added agriculture.
f) As part of the initiative toward value-added systems, there is increased focus on the creation of brands, the cultivation of regional identities, the communication of a "sense of place" about the product, and differentiation via certification systems such as eco-labels (more on eco-labels below).

All of these initiatives are hallmarks of the organic ag. system, and a range of organic products utilizes many or all of the above principles. Their adoption by non-organic ag. enterprises is a testament both to the intellectual power of the ideas themselves and also to the entrepreneurial spirit of farmers to adopt any and all good ideas that will move their operations forward to profit and prosperity.

Organic Ag. is Becoming More “Conventional”

a) Organic ag., far from being a separate and distinct entity in opposition to conventional ag, in fact operates largely alongside or even “within” the conventional ag. infrastructure. Organic operators use the same roads, trucks, suppliers, processors, employers, employees, recruiters, university and extension services, water systems, electrical systems, sewer systems, banks, schools, hospitals, and a myriad of other services that were all set up to support conventional ag. In fact, any notion of organic ag. being an “alternative” to conventional is misguided. The two ag. systems work, live, eat and sleep side by side (often on the same farm!!).
b) Organic ag. is definitely moving into larger-scale operations. While many organic farms are still small, an increasing number are large.
c) The equipment, processes, procedures and techniques of organic are more similar to conventional. For example, while earlier organic farms eschewed tractors for horses (a temporary phenomenon driven by anti-technology bias, a romantic nostalgia for pre-industrial days and some late-night reading of Wendell Berry), many modern organic farms have the same air-conditioned, GPS-guided tractors as the conventional farm down the road.
d) The management of organic ag. enterprises has largely evolved from organic “life-stylers” to ag. professionals. Previously, there was a certain liberal arts, “Hippy” or “Peace Corps” aspect to organic farming. Spirited liberal arts grads with a passion for sustainability and alternative living, but no background in agriculture, fled from their suburbs and grad schools to embrace farming. They stumbled up the learning curve, some becoming excellent farmers, others burning out and returning to the cities. They embraced a belief that the core competency for the task was not farming skill but ideological passion and that passion would overcome a lack of ag. skills. Now, however, organic farming in America is increasingly done by ag. professionals who are farmers first, usually conventional, then learn the unique techniques of the organic system. This shift has also occurred along the chain of custody, in processing distribution, logistics and retail, such that those functions are now largely accomplished by people who are skilled in those tasks prior to entering the organic sphere.
e) Organic ag. and its practitioners are becoming a more regular and accepted part of the U.S. agricultural “scene.” The older alternative culture of organic created very serious cultural gaps and conflicts between organic farmers and their conventional neighbors. There was animosity, mistrust and bad feeling on both sides. Over time, however, organic has become significantly more integrated into the overall culture of agriculture. Organic and conventional growers sit side by side on city councils, school boards, church meetings, community service projects and the like. Both organic and conventional growers are more accepting and respectful of each other and increasingly depend on each other the way farmers in the same community always have.

IV. Impact of Eco-labels.

An “Eco-label” can be defined as a system to provide independent verification of an agricultural or business process that conveys some agricultural, environmental or social benefit to society, such that consumer will want to purchase the labeled product rather than an equivalent substitute. The most well-known and widely used eco-label is USDA organic certification, and it is one of the only eco-labels audited and maintained by USDA. Another USDA-sponsored program with eco-label qualities is the USDA process verification system (e.g., "Certified Black Angus), a system that can verify a process with social benefit such as 100% traceability in livestock.

There are over 100 eco-labels used in food and agricultural crops, and they fall into several broad categories:

a) Agricultural: Verifying a process that either keeps "bad stuff" out of the product or keeps "good stuff" in, or that farms in a sustainable manner.
b) Environmental: Verifying that the process used either prevents the degradation of the environment or promotes its greater health and diversity.
c) Social: Verifies that the process promotes or preserves health, economic prosperity, social equity or positive community values.
d) Humane: Verifies that the process respects and upholds the humane treatment of animals.

There are several broad reasons why labels in general, including eco-labels, are used by companies and embraced by consumers. First, consumers want protection in a market society where the philosophy of "Caveat Emptor" makes consumers wary of products whose integrity cannot be guaranteed. A label, if operated ethically, helps to protect consumers from bad products or fraudulent claims. An example of consumer protection is the *Good Housekeeping* seal of approval. Second, consumers want assurances of quality. Bad quality is frustrating, wastes money and is potentially dangerous. A label can help consumers choose products with higher quality. An example of quality is the J.D. Power and Associates award for car quality. Third, consumers seek to reduce risk. Certain products can be deadly if made improperly, and consumers seek verification of safety. An example of safety verification is the Underwriter's Laboratory seal on electrical appliances. Fourth, consumers look for a trusted authority to grant their stamp of approval on the product. "Word of mouth" is the #1 method that consumers use to learn about a new product, and the favorable word about a product by a trusted authority is highly valued. An example of this trusted authority would be a favorable review of a product in *Consumer Reports*.

Eco-labels provide valuable information for consumers in four principal ways:

1. Approval by a trusted source. Consumers are skeptical of unsubstantiated claims made by companies, and they look for an authoritative, trusted entity to back up those claims. An example of an eco-label with this principle is USDA Certified Organic.

2. Certificate of Quality/Integrity. Consumers seek verification that the quality or integrity of the product meets their requirements. For consumers seeking verification that the product is free from pesticide residues, an example would be the "Nutri-Clean" certification.

3. Political/Social Alignment. Consumers use their purchasing dollars to help enact their political and social values. They seek out and support products that align with their political and social values. The "Fair Trade" coffee certification, which guarantees a higher-than-commodity price to 3rd world coffee growers, is an eco-label in this category.

4. Branding. At its core, an Eco-label is a branding mechanism. It fulfills the central function of a brand, which is to create an emotional connection between the

consumer and the product. An eco-label helps to "lift" an agricultural commodity into a higher realm of emotional resonance with the consumer by creating emotional bonds. A coffee bean or a frozen pea can be fairy innocuous commodities. However, with branding, it's no longer "just" a coffee bean, it's a way for consumers to improve the world, to help build farmworker prosperity (Fair Trade coffee labeling), or to help preserve beautiful songbirds (Bird-friendly coffee labeling). Labels are emotional cues that tell the consumer the product is something special, something worthy of above-commodity prices. This last point, making the product worthy of above-commodity prices, is one of the ultimate aims of branding. A successful brand justifies above-commodity pricing. Fair trade coffee is worth more than other coffee. Organic frozen peas are worth more than other frozen peas. If the value of branding (price) is greater than the cost of branding (total expense), there is, or should be, economic improvement for farmers and their wares.

The previous sections outlined many of the benefits of eco-labels. However, there are pitfalls and problems to eco-labels as well. One problem is the consumer confusion created by the proliferation of eco-labels and their overlapping benefits. How does a consumer differentiate between "Nutri-Clean" certification and organic certification? Which is better – bird-friendly coffee or farmer-friendly coffee? Do I have to choose between birds and farmworkers? If one chicken breast is certified for humane animal treatment by American Humane ("Free-Farmed" system) and another by Humane Society of the United States ("Certified Humane" system) what's the difference? One reason for the plethora of eco-labels is the nascent status of the eco-label "industry." Just as there were once 250 U.S. car makers, and now only a few, so too there are many current eco-labels, which will narrow over time to a few tried-'n'-true labels.

Another problem with eco-labels is the lack of clear differentiation between labels and the lack of funding to communicate clear and distinct messages. Labels are easy to create but difficult to make successful, to make "stick" in the minds of consumers. For any brand (be it a product, service or label) it generally takes many years and a substantial financial investment to create a clear and enduring benefit for consumers. Several current eco-labels are suffering financially because they lack the financial "staying power" to make the investment over many years to create unique, compelling and memorable identities in the minds of consumers.

An additional problem for eco-labels is the risks of setting up political or social barriers that dissuade or "turn off" consumers because of disagreement with the message. Just as a social agenda attracts certain consumers, it repels others. Many U.S. consumers don't want to be drawn into the socio-economic issues of 3rd world coffee growers; they simply want a good cup of coffee. For these consumers, a strong "farmworker rights" branding is a strident message that tells them "don't buy me unless you agree with the politics of my producer." If the company establishes several equally powerful (or "strident" – choose your adjective) messages, they may be setting up several political or cultural "hoops" for consumers to jump through. Too many hoops, and the consumer base is so narrowed that there will not be enough purchase activity to sustain the brand.

One final problem for eco-labels is the issue of independence and integrity between the certifier and the product/companies they certify. Frequently, the label is set up to audit the activities of its creator or close associates of the creator. There is a risk of a "the fox guarding the henhouse" problem in eco-labels because of the intertwined values, relationships and agendas of the labels, their creators and the products those labels are designed to verify. This problem came to a head three years ago in the organic program. In the pre-USDA days, the program had been set up by a series of independent certifiers without centralized requirements, such that the boards of the certifiers frequently included voting representatives of the companies being audited. When USDA took over the system in 2002 the agency demanded an immediate end to this conflict of interest. Other eco-labels not administered by USDA might potentially lack this oversight. There could potentially be a risk of certifiers and the companies they certify being intertwined managerially, financially and socially. These conflicts will need to be eliminated for the labels to achieve true independence strength in their status and mission.

Temperate Organic Tree Fruit Production and Extension Research Trends in California

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In 2004, California organic farmers declared over $350 million in farm gate sales value according to the self-declared, fee-based registrant data set collected by CDFA California Organic Program. This production constitutes 1.3% of the total farm gate value of California agriculture in 2003 ($27.8 billion). Of over 165,000 acres of cropland (fruit, nut, vegetable, field, and other crops) declared by registrants in 2003 (an additional 58,000 acres of organic livestock grazing and pasture land was also registered in 2003), approximately 10,400 acres can be identified as producing temperate pome and stone fruit (including olives). Total declared value of this fruit production in 2003 was approximately $33.4 million (Table 1). Apples, peaches, nectarines, prunes, and plums were the top five organic fruit in declared value. Total California temperate tree fruit production is approximately 10% of the total value of organic crop production in the state.

Although the linkage of self-declared value and registration fees may result in errors and underreporting, these statewide data are useful for historical and comparative purposes. Of the top ten organic commodities ranked by value in 2003, only the value of organic apples produced in California ($12.5 million) is in the top ten ranking (Table 2). Temperate tree fruit are a smaller percentage of the organic fresh-market commodity production industry in California than in Washington and the Pacific Northwest, greatly exceeded in value by such commodities as organic grapes, lettuce and salad mix, carrots, oranges, and almonds. According to records of the largest accredited California certifier, California Certified Organic Farmers (CCOF), *certified* organic tree fruit acreage in California has grown in most categories over the past three years (Table 3), especially since 2002 national rule enforcement. It is apparent that most of this acreage is in production for the fresh market. However, according to the California Organic Program, overall registered organic acreage of pome fruit has not grown over the last six years, whereas stone fruit acreage (peaches, nectarines, apricots, prunes, plums) has grown appreciably, especially organic prunes, and overall registered acreage for organic stone fruit in California has increased by 166% since 1998.

From 2001-2003, the University of California Division of Agriculture and Natural Resources funded a small organizational budget for the creation of an Organic Farming Research Work Group (OFRWG) under a competitive call for work group proposals. Over 40 UC farm advisors, specialists, and departmental academics from four UC campuses supported the formation of the OFRWG, and currently, approximately 70 UC academic appointees list themselves as members and have summarized their expertise (see: http://www.sarep.ucdavis.edu/Organic/AllDirectory.asp). Searching this work group database at http://www.sarep.ucdavis.edu/Organic/Search.asp indicates that a small group of UC specialists and farm advisors list expertise and research interest in organic tree fruit projects: 5 in organic apples, 5 in organic pears, 8 in organic peaches, 4 in nectarines and prunes, 1 in plums, 3 in cherries, and 4 in olives. Of these pome and stone fruit extensionists, several have been formally funded since 2002 by extramural grants to the work group for direct organic research and extension activities in organic apples (Swezey), pears (Elkins), and peaches (Hasey). This report summarizes California production and acreage trends and research and extension priorities for these workgroup-funded organic tree fruit projects.

Table 1. Declared farm gate sales value, acreage, and CCOF certified acreage of ten organic tree fruit crops in California, 2003 (CDFA Organic Program and CCOF Organic Directory database).

Crop	Acreage	Value ($ million)	CCOF acreage	# of CCOF growers
Apple	4,045	12.5	1,177	100
Peach	834	7.2	488	55
Prune	1,668	3.5	1,436	28
Nectarine	306	3.3	245	24
Plum/other	404	2.1	385	45
Pear	496	1.9	468	47
Cherry	239	1.2	115	34
Apricot	647	.8	450	37
Olive	1,670	.7	na	47
Asian pear	85	.2	na	11
Total	10,394	33.4	4,764	428

Table 2. Top ten organic crop commodities in California, self-declared value and acreage, 2003 (CDFA Organic Program database).

Crop	Acreage	Value ($ million)
Table grapes	2,597	32.3
Salad mix	5,267	30.4
Strawberries	1,290	24.6
Carrots	4,023	22.5
Lettuce	3,692	16.3
Rice	14,390	14.7
Wine grapes	7,875	14.4
Oranges	3,182	14.4
Apples	4,045	12.5
Almonds	3,597	12.3

Table 3. Growth in CCOF certified acreage of pome and stone fruit, 2002-2004, CCOF Handbook, 2004.

Fruit	2002	2003	2004	3-year % increase
Apple	1,037	1,177	1,162	12
Pear	400	468	516	29
Total	1,451	1,645	1,678	
				2-year % increase
Peach	354	488	616	26
Nectarine	na	245	350	43
Cherry	na	115	167	45
Apricot	na	450	438	-3
Prune	na	1,436	1,415	-2
Plum, other	2,261	385	1,256	326
Total	2,615	3,119	4,242	36

Table 4. Growth in registered organic temperate tree fruit acreage, California Organic Program database, CDFA, 1998-2003.

Fruit	1998	1999	2000	2001	2002	2003	6-yr. % increase
Apple	4,067	4,610	4,423	4,853	3,871	4,045	-1
Pear	519	522	645	662	540	494	-4
Total	4,586	5,132	5,068	5,515	4,411	4,541	-1
Peach	657	432	535	644	688	834	+27
Nectarine	306	134	172	202	251	306	0
Cherry	145	157	198	198	213	240	+14
Apricot	240	398	511	481	656	647	+270
Prune	531	582	816	1,604	1,724	1,668	+314
Plum	239	218	321	375	369	404	+169
Total	2,118	1,921	2,553	3,504	3,901	3,519	+166

Organic Apples

California apple production represents 4% of national production (California= $78 million in 2003), and apples are produced on approximately 28,000 bearing acres, according to national statistics (see: (ftp://www.nass.usda.gov/pub/nass/ca/AgStats/2003cas-ovw.pdf). Registered organic production occurs on 4,045 California apple acres, constituting 15% of bearing acres. A decline of nearly 20,000 bearing conventional apple acres has occurred in the last decade. Major organic production counties include Mendocino, Santa Cruz, San Luis Obispo, Fresno, and Sonoma. Cost of production studies for Sonoma and Santa Cruz County growing conditions can be found at: http://www.sarep.ucdavis.edu/pubs/Costs.htm. A total farm gate value of $12.5 million was declared by registered organic apple growers in 2003 (16% of overall statewide apple farm gate value). Organic apple acreage is the largest percentage of total declared value and acreage dedicated to organic production of any temperate tree fruit commodity in California. Although growth in certification, largely for the fresh market, has been recorded by CCOF over the past three years, no net growth in total registered acreage has been reported to the CDFA Organic Program over the last six years. Approximately 7,000-10,000 fresh market bins are produced statewide every year, and 25-30,000 bins of processing fruit are produced each year (Denevan, personal communication). In the Watsonville area, 4-5,000 fresh market bins are processed in the largest dedicated fresh market organic apple packing facility. Fresh market apples are brokered from this facility (B.A. Rider and Sons) by CF Fresh. It is estimated that approximately 1/3 –1/2 of the fresh market crop is brokerage fruit, 1/3 is direct marketed to the public, and the remaining crop is marketed through miscellaneous channels to supermarkets and other retail outlets. Dominant fresh market varieties in the Watsonville area are Jonagold, Braeburn, Fuji, and more recently Honeycrisp. Processing fruit is used for organic juice production by processors such as Martinelli's, Knudsen, and others, while baby food manufacturers (Gerber, Earth's Best, etc.) also purchase California organic apples. Prices for processing fruit are in the range of $220-$250/ton in the Watsonville area.

In 1990, farm advisors Janet Caprile, Paul Vossen, Walt Bentley and specialist Sean L. Swezey formed a statewide research team to study regional organic apple production models in their respective regions. Initial trials concentrated on the use of pheromone-based mating disruption of codling moth, and the technology was widely adopted for organic production by the mid-1990s, with supplemental controls necessary in warmer production districts. Vossen's and others' trials with sulfur, minerals, oils, microbials, botanicals and soaps were designed for evaluation of organic control of diseases (scab), nutritional deficiencies (bitter pit), aphids and leafrollers. Vossen has also trialed successful orchard floor management techniques for weed control including: fabric or organic mulches, cultivation, flaming, and irrigation management. Disease resistant varieties and various rootstocks were planted under organic management in several on-farm Sonoma County organic orchard trials, currently most notably at the Santa Rosa Junior College Shone Farm. Those same trials have also documented a variety of cover crop and weed control options for organic apple growers. Caprile's long-term studies of introduced parasitoid mortality of codling moth in organic orchards in Contra Costa County have documented the basic expectation and magnitude of additional biotic mortality (6-12%) due to parasitoids in pesticide stress-free apple production systems (http://www.sarep.ucdavis.edu/CCBCposters.pdf. p. 52). Adequate organic apple tree nutrition has been reliably provided by cover cropping and compost application in most California situations. An organic apple production short course in 1998 led to the publication of the Organic Apple Production Manual (UC-ANR Publication 3403) and a yearly "Moth Madness" organic apple production extension meeting is held in March in Watsonville. California organic apple growers now have a reliable inventory of organic production methods and a system based primarily on a decade of organic-specific research. Currently, organic spray thinning issues, scab spray timing and associated fruit russeting in wet years, control of eye-spotted bud moth damage to organic apples on the Central Coast, cost and availability of supplemental codling moth controls (spinosad, granulosis virus, kaolin clay, etc.), and new early-ripening varieties for California organic market windows are being investigated or remain as research priorities. An update or revision of the UC organic apple production manual (2nd edition) has also been considered.

Organic Pears

California conventional pear production ranks second in the nation, approximately 29% of the national production total. Pears were produced on over 17,000 bearing acres in 2003 at a farm gate value of $63 million. Over the last decade, California pear acreage has declined by 27% due to declining prices and cost of production issues in many production areas. Registered organic production occurs on 3% of total state acreage and has remained at this level for the past six years, according the state registrant data base. A total of $1.9 million in sales was declared for organic pears in 2003. Organic pear acreage and value are thus considerably smaller than organic apple acreage in California. Mendocino, Lake, and several Sacramento Valley counties are the major production areas. Recent efforts of growers to place blocks of pear orchards in Sacramento, Solano, and Sutter counties under organic management in an attempt to find other markets for their declining sales have been noted. Some 2-3,000 bins of organic pears statewide are packed for the fresh market, with approximately half of this total, mainly Bartlett pears, brokered by CF Fresh. Processing fruit prices are in the range of $250-$280/ton and baby food and juice manufacturers purchase this fruit.

UC Farm Advisor Rachel Elkins of Lake County has recently initiated organic pear research efforts under workgroup funding. Her research results and priorities from efforts in Lake and Mendocino Counties are summarized as follows:

1) Codling moth control with organically compliant virus (CMGV) formulations. Codling moth granulosis virus was tested for the third year in Lake County pear orchards in 2004, including a transitional orchard. These results were summarized in a poster presented at the California Conference on Biological Control and Organic Farming Conference, held in July 2004 at UC Berkeley (http://www.sarep.ucdavis.edu/CCBCposters.pdf. p. 35). Control programs always were comprised of mating disruption with supplemental materials. Results show that organic pear growers have several options to effectively supplement pheromone mating disruption, including oils, CMGV, spinosad, and kaolin clay. The eventual availability of CMGV formulations and spinosad will allow organic growers to effectively supplement mating disruption for codling moth control. See poster at: (http://www.rics.ucdavis.edu/fnric2/crops/OrganicCMPoster_Elkins_07_04.pdf)

2) Organic pear variety trial. A pear variety trial begun several years ago is in an orchard that became certified organic in 2004. Observations have been initiated on how various varieties respond to organic inputs. For example, will sulfur used for pear scab control cause unacceptable russeting? Will fruit size be affected? Will key insect pests become more or less of a problem? Will the lack of NAA as a stop drop cause fruit to drop prematurely? Sensory evaluations on several varieties and survey data are being obtained and information has been collected from organic pear marketers on the retail and consumer preferences of their clientele.

3) Organic pear fire blight control. Field trials in 2004 continued to test *Pseudomonas syringae* A506, a biological control agent for fire blight, frost, and russet control in pears. The commercial product, Blight Ban A506, is OMRI listed. It will be of major importance to organic pear growers if current antibiotics are de-listed or fire blight bacteria become resistant to them. In addition to the ongoing A506 research, Elkins worked with the distributor of antibiotics used to control fire blight to get their products re-listed by OMRI. Previously, only the generic category "antibiotics" was listed, so no actual formulated products were available for use.

4) Authorization of EQIP funds for pheromones for organic growers. Lake County farmers, including organic, can now receive EQIP funds for integrated pest management, specifically pheromone mating disruption and monitoring. This support is important to organic growers. Organic growers can now apply for up to $200 per acre for pheromones and for additional cost share on field monitoring.

5) Organic Pear Production Short Course was held in February 2004, with 50 attendees. A course binder was given to each participant, which will be the basis of a future UC Organic Pear Production Manual.

Peaches and Other Stone Fruit

California leads the nation in the production of all major stone fruit except cherries. Nearly all organic stone fruit have shown registered acreage increases over the past six years in California, and organic stone fruit growers declared a farm gate sales value of $18.1 million in 2003, of which $7.2 million of sales were organic peaches, followed by $6.8 in plums and prunes combined. Combined *conventional* sales of the major California stone fruit crops listed in Table 1 were $787 million in 2003 with increased sales value over the past three years of all crops except nectarines, apricots, and prunes. Total registered organic stone fruit crops grown on 3,519 acres comprise only 1% of over 250,000 conventional acres in California and 2% of conventional sales value. Major organic production counties are Sutter/Yuba (prunes, peaches), Butte (prunes, peaches), Fresno (peaches), and Tulare (combined stone fruit).

UC Farm Advisor Janine Hasey of Sutter and Yuba Counties has recently initiated organic peach research efforts under workgroup and Gerber Products funding, with the assistance of Roland Meyer, Soils Specialist, UC-Davis. Research results and priorities from organic stone fruit activities in Sutter/Yuba are summarized as follows and a report of this research can be accessed on page 34 at:

http://www.sarep.ucdavis.edu/CCBCfinal.pdf.

An organic no-till cling peach transition study was begun in 2001 with an emphasis on nutrition of newly planted trees. Sub clover orchard floor seeding treatments and chicken manure compost additions provided adequate nitrogen for significantly increased tree growth (in the 2.75% or higher leaf concentration range). Sub clover seeding yields the highest biomass and is the least costly floor management system for newly planted peach trees. However, production inputs such as fertilizer and weed control were more costly, and polypropylene fabric and cross mowing were most successful for weed management. Under mating disruption and microbial control, arthropod pests such as oriental fruit moth and peach twig borer can be effectively controlled. Due to observations in this study pertaining to weed competition, it is suggested that it is easier to transition an already established conventional peach orchard. Weeds are not problematic in organic peaches once there is shade from the tree canopy.

Organic Peach Production Outreach

In February 2004, an organic fertility seminar was held in Yuba City to present an overview of considerations and choices available to the organic fruit growers for managing soil fertility, including the roles of soil amendments, composts, manures and cover crops. Also presented were guidelines for taking soil and plant samples and information on how to interpret and use soil and plant test results for organic production. In May 2005, an organic tree fruit field day was held at the UC Sierra Foothill Research and Extension Center in Sutter County. The Center, located at an elevation of approximately 600 feet above the valley floor, has a one-acre planting of pome and stone fruit varieties, managed organically since 2001. Under co-management by the Center and local organic producers, this organic variety trial and demonstration plot is unique in the University system for its organic research focus and community involvement, stressing early harvest stone fruit varieties (Sun Crest, Red Haven) for organic management to avoid mid-season fungal disease problems.

Pacific Northwest/Colorado/British Columbia—Regional Report

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Washington State now has over 10,000 acres of organic tree fruit in production. As of 2004 approximately 7049 acres of apples were certified with another 844 in transition. This constitutes what is likely the largest concentration of organic apples in the world. For pears, in 2004, approximately 1509 acres were certified with 201 in transition and for sweet cherries approximately 581 acres were certified with 158 in transition. Other organically cultivated tree fruits in Washington include peach, apricot, nectarines and plums/prunes. Organic acreage now constitutes about 5-7% of total Washington State tree fruit plantings. Acreage has been growing steadily but erratically for a decade, with some years experiencing a doubling and others relatively unchanged.

Though there has long been an established organic tree fruit farmer constituency in Washington, most orchardists now farming apples, pears and sweet cherries in organic systems came to organic production as a response to economic/marketing adversity. The first big wave, in 1989-1990, of apple farmers shifting from conventional production systems to organic systems occurred in response to the Alar episode. After the collapse of Washington's apple markets resulting from negative public reaction to the use of the growth regulator Alar, many producers tried organic farming as a means to avoid being caught up in such a debacle again. However, lack of effective tools to control codling moth led to minimal retention of these growers in organic production.

The second, more recent wave of conversion to organic production methods (1996- 2002; primarily apple and pears) has been motivated by economic hardship and the desire to participate in profitable farming ventures. In 2000 and 2001 organic apple acreage increased by approximately 1900 and 2300 acres respectively and the year proceeding and year after both exhibited 500 acre increases. Thus, in four years Washington organic apple acreage went from 1800 to 7000. The Food Quality Protection Act, when fully actualized, may well spur a third wave. Also, the differences between organic and conventional have been shrinking with the availability of new tools and techniques.

Red Delicious was the dominant cultivar grown organically in 2000 (1500 acres) but has steadily declined (985 acres in 2004) while other cultivars, including Gala, Fuji, Granny Smith, Golden Delicious, Braeburn, Pink Lady, Cameo and Honeycrisp have increased. Fuji and Gala are the top two organically grown cultivars today.

Growers have largely sought to mitigate lack of profitability, due to oversupply, by moving into the expanding domestic organic market and capturing the premium organic tree fruits have long garnered. The Washington Apple Commission reported that organic apple, though representing a small percent of overall apple sales, has been the only growing apple category in the domestic market in recent years, exhibiting growth rates approaching 500% annually. Unfortunately, this strategy has already backfired somewhat in that the mainstream organic apple market is now oversupplied and the former premiums are no longer realized. Thus profit margins for conventional and organic apples are equalizing down as acreage and production expands. Traditional and smaller organic apple growers are particularly feeling the effects of the entry of the large, vertically integrated grower/packer/shipper into the organic market.

Certainly mating disruption for the management of codling moth has been pivotal in the shift of conventional apple producers to organic production systems. Virtually 100% of Washington's organic apple producers utilize mating disruption for codling moth management. It is doubtful that the recent expansion of organic apple production in Washington would have occurred without mating disruption technology.

Washington's sweet cherry acreage has increased substantially in recent years (as farmers switch from apple) and likewise organic sweet cherry acreage is increasing. The growth in organic production of sweet cherry may be occurring primarily as a hedge against declining margins in an increasingly well-supplied sweet cherry market. And similar to apple, the development of new materials for the management of cherry fruit fly will spur expansion.

In British Columbia, Canada, there are approximately 1000 acres of certified organic apples with another 30 in transition. There are also approximately 50 acres of certified pear and 50 acres of certified soft fruit. These plantings are exclusively in the semi-arid Okanagan and Similkameen Valleys of interior British Columbia. Supporting B.C.'s organic tree fruit industry was the recent publication of the book *Organic Tree Fruit Management* by Linda Edwards (ISBN 0-7726-3615). The Certified Organic Association of British Columbia in Keremeos, B.C., Canada, published this comprehensive guide in 1998.

Estimates for Oregon organic tree fruit plantings (in 2004) indicate 125 acres of apple, 200 acres of pear, 100 acres of sweet cherry and 163 acres of plum/prune. Another 65 acres are in transition. Thus, in Oregon there are approximately 650 acres of organically cultivated tree fruit, mostly located in the Hood River, The Dalles, and Willamette Valley areas.

Colorado has experienced a substantial decline in organically managed tree fruit plantings. In 2001 the Colorado State Department of Agriculture reported 1023 acres of organic tree fruit including 635 acres of apple. In 2004 they report a total 304 acres of organically grown tree fruit comprised of 130 acres of apple, 113 acres of peach, 25 acres of pear, 23 acres of sweet cherry, 7 acres of apricot and 6 acres of plum.

Certainly, as previously mentioned, advances in production technologies, most notably key arthropod pest management tools, have facilitated/stimulated growth of organic tree fruit production in this region. It is worth noting that these pest management advances were not pursued with organic production in mind but rather in support of moving conventional production systems to 'softer' IPM. However the resultant growth in organic production now increasingly stimulates research. The Washington Tree Fruit Research Commission sees the organic sector as a significant, expanding component of the tree fruit industry and supports research of relevance to organic producers, especially focusing on the unique challenges they face (e.g., blossom thinning). In Oregon, organic crop producers are encouraging Oregon Sate University to expand its organic research focus and efforts. As a number of researchers have noted, conventional and organic tree fruit production systems are increasingly convergent and the lines between them increasingly blurred. Thus many of the tree fruit production investigations conducted in this region have potential to benefit organic and conventional producers alike. That being said, there is also substantial research conducted exclusively in support of/to advance organic production. In our region research relevant to organic production is focused mostly around arthropod pest management, weed and orchard floor management, and crop load management. To a lesser extent there is research on soil health and nutrition, vertebrate pest management, and postharvest issues. Disease management and economics are underrepresented.

The following will briefly summarize recent research projects that support, either directly or indirectly, organic tree fruit production. By no means is this an exhaustive summation. More complete descriptions of many projects will be presented in the symposium poster session and included in the symposium proceedings. It is noteworthy how many of these projects relate to one another.

Arthropod Pest Management

Management of codling moth, the key insect pest of apple, continues to be an important research focus. Jay Brunner (WSU, Wenatchee, WA) and others continue their pioneering work on effective use of pheromones for management of the pest. Current research includes the evaluation of mating disruption in various treatment combinations/strategies that include Entrust (spinosad), mineral oil and CM virus in organic orchards with severe codling moth pressure (5-75% crop loss). Lerry Lacey, USDA insect pathologist (Wapato, WA), is assessing various full season granulovirus programs for CM management in comparison to conventional management programs. Lacey also conducted a recent study in the mulching trials of Granatstein (WSU, Wenatchee, WA) and Mullinix (WSU, Wenatchee, WA) to evaluate the efficacy and persistence of two entomopathogenic nematode species on control of codling moth larvae as affected by various mulch treatments.

In apple orchards using mating disruption for CM management, leafrollers often become the most problematic pest. Tom Unruh, USDA entomologist (Wapato, WA), is investigating enhancement of leafroller parasitism via the establishment of native rose and domestic strawberry plantings in proximity to the orchards. The plantings serve to support resident populations of the strawberry leafroller, an alternate host of the parasitoid wasp *Colpoclypeus florus,* thus increasing parasitoid populations and apple leafroller parasitism in spring and summer generations. Results have been mixed and Unruh seeks to determine the parameters and considerations for optimal garden placement, establishment and management. Mullinix, Brunner and Isman (UBC- Vancouver, B.C.) recently evaluated apple leafroller (as well as other arthropods) population dynamics and parasitism over a four-year period in 1.5 acre orchard plots managed with mating disruption for CM, no insecticides and with either a grass or alfalfa cover. Leafrollers came to infest 100% of shoots by year three. In year four leafroller populations crashed and all but disappeared. All other arthropod pest species never achieved pest status. Vince Jones (WSU, Wenatchee, WA) is investigating the phenology of apple leafrollers, identifying the parasitoid complex of leafrollers and delineating sampling parameters for them.

John Dunley (WSU, Wenatchee, WA) focuses his work on pear production and arthropod pest management and is leading Peshastin Creek pear growers in the development of an areawide organic management program. He is comparing an organic pear production system with soft and conventional systems. Included in the evaluation are economic, management, yield, fruit quality, and grower satisfaction aspects. CM was initially problematic but has been successfully brought under control; however pear rust mite remains a significant limitation in the soft and organic systems. Biological control of pear psylla is also an emphasis of this ongoing project.

The key pest of sweet cherry is the cherry fruit fly. Tim Smith (WSU, Wenatchee, WA) has been investigating the use of GF-120 NF Bait (a.i. is spinosad) as a control option for western cherry fruit fly in organic and conventional orchards. He has found it to be highly effective after testing the material in high pest pressure conditions. GF-120 is now used in virtually 100% of organic sweet cherry orchards in Washington State. This is a very important pest management innovation with the potential to encourage organic production of sweet cherry, similar to the effect mating disruption had on organic apple production.

Western flower thrips is an occasional direct pest of apple and to a significant extent encumbers the organic production of light colored apples, particularly Granny Smith. Elizabeth Beers (WSU, Wenatchee, WA) is studying the biology, migration and management of western flower thrips. Beers intends to assess the mobility of thrips in and between orchards, determine the efficacy of managing alternate hosts in orchard ground covers during bloom time to enhance biological control, and determine the periodic susceptibility of apple fruit to oviposition injury.

Linda Edwards (British Columbia) reports that in the Similkameen Valley of British Columbia rosy apple aphid is regarded as the most important insect pest of apple. Amanda Brown (UBC graduate student, Vancouver, B.C.) is working with Cawston, B.C., area organic apple growers to assess biological control and management of alternate hosts for this insect pest.

Weed and Orchard Floor Management

Weed management continues to be a challenge in organic tree fruit production. Mechanical weed control has been the standard in organic orchards despite associated deleterious effects to the soil and plant root system and high cost. Various mulching materials and living mulches are utilized for weed control, water conservation and enhanced tree growth but can compete with trees and harbor rodents. Several researchers cognizant of this research priority are working in this area.

Rick Zimmerman (CSU, Hotchkiss, CO) is investigating the efficacy and economic feasibility of direct flame and infrared heat for weed control in orchards. Zimmerman and Bob Hammond (CSU, Grand Junction, CO) are evaluating the biological control of field bindweed with an eriophyid mite. Also in Colorado, Ron Godin (CSU, Hotchkiss, CO) has completed a project evaluating various mulch materials for weed control in non-herbicided orchards. Included were bark, landscape fabric, shredded paper, and alleyway mow and blow (under tree) mulch treatments. Additionally Godin has initiated evaluation of corn gluten meal applications as a weed seed germination inhibitor and intends to evaluate the herbicidal activity of acetic acid (30% conc.).

In British Columbia, Gene Hogue (Agriculture and AgriFood Canada, Summerland, B.C.) and colleagues have also investigated the use of various mulching materials in orchards for weed suppression and water conservation, in comparison to standard glyphosate-based management. Notable in Hogue's treatments was a spray-on paper mulch made from newsprint residual. On the orchard floor it looks much like paper maché. Hogue concluded that surface mulches can improve fruit tree growth and the spray-on mulch in particular enhanced growth of newly planted trees. Granatstein, Mullinix and Kirby (WSU, Wenatchee, WA), in cooperation with Hogue, have also been investigating the use of various mulching materials including shredded paper, alfalfa hay, chipped tree waste (from landscape services) and living mulches. They screened 26 potential living mulches and this spring established a new trial to evaluate various perennial covers, including legumes, in a sandwich configuration and under the entire tree row.

Dave Horton (USDA, Wapato, WA) is investigating the effect of orchard cover mowing frequency on insect dynamics in pear orchards and Mullinix, Brunner and Isman, in their leafroller biocontrol study (see above), found no appreciable difference between grass and alfalfa cover relative to insect pest dynamics. As mentioned above, Beers is evaluating the management of alternate hosts of western flower thrips in orchard ground covers and Zimmerman is, this season, completing an on-farm, organic orchard cover crop/fertility study.

A major barrier to the uses of mulches and cover crops is their creation of excellent habitat for orchard voles (and other pestiferous rodents). Granatstein, Tom Sullivan (UBC, Vancouver, B.C.) and Mullinix are initiating studies to assess the ecology of orchard voles and to identify and test potential mechanisms, other than the conventional means of poisoning, to regulate their populations in organic systems.

Crop Load Management

Chemical thinning to prevent alternate bearing, enhance remaining fruit crop and reduce labor costs associated with hand thinning continues to be an important element of apple cultivation. Organic growers have far fewer crop load management options than do conventional growers.

Since 1999 Jim McFerson, Tory Schmidt, Tom Auvil and Felipe Castillo of the Washington Tree Fruit Research Commission (Wenatchee, WA) have conducted over 200 chemical thinning trials on apple, pears, sweet cherries, peaches, nectarines and apricots, in over 70 sites, throughout Washington. Most were focused on bloom thinning. A significant number of their trials have been conducted in certified organic orchards (20) and thus only organically acceptable materials were tested. They estimate that about 75% of the 30-plus materials and material combinations they have evaluated are approved for use in organic systems. These same materials are tested in conventional orchards as well. From 1998 to 2000 their work focused on lime-sulfur and oil programs and resulted in the popular use of lime-sulfur + oil and lime-sulfur alone thinning programs. In fact a lime-sulfur formulation plant has now been built in Washington to meet demand for this organically approved blossom thinner. Ongoing WTFRC research seeks to refine lime-sulfur thinning programs and to evaluate lime-sulfur as a post-bloom thinner. Similarly, graduate student Christina Machial (UBC, Vancouver, B.C.), under the supervision of Murray Isman, is evaluating the potential of plant essential oils as apple thinning agents. They have just initiated research to evaluate the efficacy of Matran, a commercial herbicidal formulation of clove oil, as a blossom thinner. Matran and other plant essential oils are permitted for use in U.S. organic production but not in Canada.

Soil Health and Plant Nutrition

Apple replant disease mitigation in any system is problematic. To organic producers, the disease syndrome presents a particular impediment to viable and economic production. Management of replant disease is a distinct challenge to organic apple growers in that available treatment options are severely limited. Some growers choose to fumigate their soil before replanting to avoid the risk of a poor performing orchard and thus restart their certification clock. Understanding soil ecology and the potential to manipulate the soil microbial community for replant disease management have come to the forefront.

Mark Mazzola (USDA, Wenatchee, WA) has been exploring bio-remediation of apple replant disease for some time. Mazzola has identified specific microbial organisms and complexes that cause replant disease and, further, has investigated the use of *Brassica napus* seed meal and green manure amendments to favorably shift soil microbial community composition. He is now focused on understanding the structure and function of microbial communities resident in orchard soils and on developing strategies to enhance populations and activities of specific microorganisms in a manner that promotes plant growth directly or indirectly through suppression of plant diseases.

The identification of genetic resistance to components of apple replant disease may yield valuable alternative mitigation strategies, particularly in organic orchards where treatment options are limited. Gennaro Fazio (USDA, Geneva, NY), Mark Mazzola, Dana Faubion (WSU, Yakima) and Tom Auvil are testing the genetic tolerance of apple rootstocks to replant disease. These tests are being conducted in various orchard systems, including organic, in Washington. They feel that the identification of rootstocks that are adapted to organic cultural practices is extremely important.

Julia Roberts, UBC graduate student (Vancouver, B.C.), in cooperation with approximately 20 organic apple growers in Cawston, B.C., has just completed a bioregional, organic orchard soil health assessment project. This resulted in the creation of a mechanism to help organic tree fruit producers assess their soils and guide their efforts to improve soil health. They also had the objective of determining if mandatory soil tests, required by certifying bodies, were sufficient and/or relevant. The program is reported to have resulted in changes in farmer soil building and tree fertilization practices.

Sarah McDonald (OSU, Corvallis, OR), Ann Chozinski (OSU, Corvallis, OR), Anita Azarenko (OSU, Corvallis, OR) and Tom Forge (AgriFood Canada, Agassiz, B.C.) have conducted a study to assess how alternative orchard floor management practices (four treatments with mechanical weed control) affect soil quality, especially soil biological characteristics. They utilized nematode diversity assessment as an indicator of soil community structure, soil food web character and decomposition pathways. Forge has also worked on evaluation of mulches and soil amendment effects on soil micro flora and fauna in other research.

In Colorado organic peach orchards, Godin evaluated various nitrogen sources including on-farm grown alfalfa, a 12-2-0 animal byproduct material (Naturesafe), yellow sweet clover grown in the drive alley, berseem clover grown in the drive alley and Naturesafe/ alfalfa mixes.

Frank Peryea (WSU, Wenatchee, WA) and John Dunley have undertaken studies to assess mineral nutrition in organic, soft and conventionally managed pear orchards as part of Dunley's areawide project. The detection of N nutrition deficiency symptoms in organically managed blocks prompted this study. Leaf samples from 39 d' Anjou orchards were analyzed for N, P, K, Ca, Mg, S, Zn, B, Mn, Fe, Cu, Al, and Na. Orchard management system influenced various leaf mineral concentrations. Peryea is also investigating the phytoavailability of zinc in commercially available sprayable zinc fertilizers utilized in apple orchards.

Rita Yastermski and Bill Wolk, both of British Columbia, are working with organic ‘Ambrosia’ apple growers conducting fruitlet mineral analysis to determine critical nutrient levels for optimum fruit quality.

Disease Management

Generally speaking, little is being done in this area. Sulfur and copper treatments remain the mainstay organic treatments for fungal and bacterial diseases. However, in British Columbia, Mario Lanthier (Crop Health, Inc., Kelowna, B.C.) is investigating the use of compost tea for management of powdery mildew in apples and as a way to increase fungal populations in orchard soils to enhance tree growth. Chang-Lin Xiao (WSU, Wenatchee, WA) is working on a proprietary biocontrol agent for fungal pathogens.

Postharvest

Lisa Neven (USDA, Wapato, WA), with collaborators, has developed over the last ten years a controlled atmosphere temperature treatment system as a quarantine treatment for fruits against internal feeding insect pests such as codling moth, oriental fruit moth, western cherry fruit fly, and apple maggot and plum curculio. Treatment of apple, cherry and nectarine has been demonstrated and confirmed effective in killing respective insect pests while maintaining fruit quality. Tests on apple have been exclusively performed on organically produced fruits. It is the only quarantine treatment that can be used to meet quarantine restrictions for organic fruits.

Avian Pests
Fred Provenza (USU, Provo, UT), Mullinix and Granatstein are discussing the development of research to explore the modification of the fruit feeding behaviors of birds in cherry orchards.

Organic Systems
John Reganold (WSU, Pullman, WA) and Preston Andrews (WSU, Pullman, WA) led an extensive study, which was reported in *Nature*, comparing organic and conventional apple production systems. They found organic systems to be economically comparable to conventional systems, and organic systems conferred substantial environmental benefits. They are now following up on this study with the evaluation and comparison of quality and taste of fruit produced in various systems.

Organic Fruit Production in South America

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South America is overall a net exporter of organic fruits due to the contributions of Argentina, Chile and Brazil. While Argentina and Chile contribute with diverse fruit crops, Brazilian exports focus on citrus, especially concentrate orange juice.

Situation in Argentina

Argentina has a privileged position to develop organic agriculture due to its diverse climate and ecological conditions for various crops and its extensive production systems which have traditionally used small quantities of agrochemicals and which do not require significant changes for the conversion from traditional to organic agriculture.

During the past few years, organic production in general has been growing significantly at 25-30% annual rate, compared to conventional agriculture whose annual growth rate is about 2%. However, Argentina's share of the total world market of organic products is only 0.1%. The domestic market is also growing, but at a lower pace. Approximately 90% of Argentina's organic production, estimated at 34 million dollars, is exported and the remaining 10% is destined for domestic consumption.

Argentina was the first country in the Americas to establish in 1992 its own standards for the certification of organic products equivalent to that of the EU and validated by the International Federation of Organic Agriculture Movements (IFOAM).

In mid-1992, Argentina submitted a request to the European Commission to be included in the equivalence list of third countries provided for by Article 11 (1) of EC Council Regulation No. 2092/91. Based on analysis of the production rules and inspection system by the EC, Argentina was placed on a provisional list of third countries at the end of 1992. In 1996, Argentina was officially included in the EC list of equivalent third countries (FAO, 2001).

The oldest farmer organization is MAPO (Argentine Movement for Organic Production). MAPO has together with SENASA played an important role in the formulation and implementation of the National Program for the Development of Organic Agriculture in Argentina. Argentina's organic production is officially governed by the National Service of Agricultural and Food Health and Quality (SENASA). A law prohibits marketing of organic products which have not been certified by a SENASA-approved certifying agency.

For an organic food product to be imported into Argentina, it must be recertified by an Argentine certifying company approved by SENASA. All imported organic products entering Argentina must comply with the above-stated regulations, which include a certificate from the country of origin stating that the product has been certified as organic. In addition, the country of origin must have official recognition of its organic standards as equivalent to Argentina's.

Consumption. No formal market research has been carried out either by the Government or the private sector on the profile of consumers of organic food products. The average Argentine consumer is price oriented. Therefore he is not prepared to pay more for a product for which he does not feel a need or perceives as better. Organic consumers belong to either a higher-income strata or are vegetarians.

Fruit crops. Argentina is one of the world's largest producers of certified organic apples and pears, with near 2,000 ha. Total production of certified organic apples and pears reached approximately 7,400 metric tons in 1999 and the figures rose to 14,000 metric tons in 2003 driven by rapidly growing demand by the main export destinations, i.e., the EC and the United States. So far, exports to Japan have been limited (SENASA, 2004).

Production constraints. First, access to credit, especially for small farmers, is virtually impossible since interest rates are ranging between 24% and 36% annually. These rates prevent major investment (in organic production as well as in other sectors).

Second, many producers complain about the limited availability of bio-pesticides. SENASA, the competent authority for accreditation of organic certifiers, publishes a list with all the allowed products. However, foreign products are required to be tested during at least three years at the Argentine research institutes (INTA) before they can be included in the list. Although pest pressure is generally low, the lack of sufficient means to combat pests in an organic way decreases the yield and therefore the profit.

Third, although the organic sector has increased strongly, it is still a relatively young and inexperienced sector. There are a few research projects on appropriate organic farming methods under local conditions and extension assistance is virtually absent. The main research group is located in the Upper Rio Negro Valley and works on both research and extension. However in most regions, growers start producing organically on a trial and error basis and adjust their farming methods every season.

In such cases the expected low yield, especially the first few years of production, represents the highest costs growers face, much higher than other costs, such as certification and inspection.

Support to production. The Government of Argentina does not grant any subsidies or incentives to agricultural production, including organic production. There are no Government or private sector sponsored activities designed to educate and encourage consumers to purchase organic products. However, in September 1998, the Argentine Agricultural Secretariat (SAGPyA) launched the National Program for the Development of Organic Production (PRONAO). This program, which does not exist anymore, aimed to promote organic products in the domestic market, increase the number of organic producers, capture new markets and educate consumers.

Situation in Chile

The area under organic fruit production in the 1999/00 season was estimated at 683 ha. In 2003 the total area increased to 4,172 ha. Other major organic fruits include wine grapes (1,914 ha), avocado (542 ha) and apple (519 ha) (Hernández, 2000; Eguillor Recabarren, 2004).

Government agencies. The Servicio Agrícola y Ganadero (SAG) of the Ministry of Agriculture (MOA) is the leading Government agency for the organic sector. It has established a National Certification System to verify compliance with official regulations governing organic production.

Another important agency is the Ministry of Foreign Affairs through its export promotion agency ProChile. The objective of ProChile is to promote Chilean exports, especially non-traditional (i.e., "new") exports. Since 1995, when an Agricultural Export Promotion Fund was established by the Ministry of Foreign Affairs, promotion of organic products abroad has been included in ProChile’s program. ProChile sponsors activities such as workshops and seminars and represents the organic sector in international trade fairs and exhibition.

Organic certifiers and other organizations. In early 2001, four organic certifiers were active in Chile: two national and two international. The two national certifiers are CCO (Certificadora Chile Orgánico) and PROA (Corporación de Promoción Orgánica Agropecuaria). Both were established in the early 1990s, and during most of the past decade, these were the only two certification bodies in the country. A few years ago, two foreign certifiers established representation in Chile: the German certifier BCS and the Swiss certifier IMO.

The SAG of the Ministry of Agriculture has formulated regulations for organic production in Chile. Moreover, it has established a National Certification System to verify compliance with those rules.

The two official regulations that apply to organic farming in Chile are: "Chilean Norm NCH2439 Production, processing, commercialization and labeling of organically produced foodstuffs" and "Chilean Norm NCH2079: General criteria for certifying organic production, processing, transport and storage systems." The regulations, in place since May 1999, give definitions of basic production, processing and labeling standards, as well as control and inspection requirements, among others.

The Chilean organic regulations are based on existing organic rules in the EC and the United States, and the Chileans claim these rules to be equivalent to EC Regulation No. 2092/91 and EN 45011 or ISO 65 (SAG, 2000b).

Industry facts. Most organic fruit growers are small and medium size. More than 80% of organic farms are smaller than ten hectares (Hernández, 2000).

The major enterprises responsible for packing, processing and commercialization of the products (mostly exports) are those which are conventional processors and exporters who have started with a separate product-line (or -treatment) alongside their conventional activities. Specialized organic traders and processors, seen in many European countries and in the United States, are not common in Chile.

Marketing organic fruits. Government sources have indicated that for organic production in general, an estimated 60% is exported and 40% is for domestic consumption (FAS, 2000). However, for certain products, e.g., apples, the report states that (according to some producers) organic apples are produced for export only.

No precise information on the domestic organic market is available but reliable sources say that its size is rather insignificant. The Chilean market for food items in general, and for fruits and vegetables in particular, is dominated by large super/hypermarket chains, which try to attract consumers through aggressive price discounts.

The main destination is the United States market, accounting for almost 70% of all fresh organic horticultural exports from Chile. The second most important destination is Europe, while "other" countries (i.e., Japan and Canada) accounted for only 7% of organic fruit and vegetable exports in the 1999/00 season.

Constraints to exports. Export constraints are not among the greatest limiting factors for growth of the Chilean organic sector. The country has a worldwide image of being a significant exporter of (conventional) agricultural fresh (e.g., apples and grapes) and processed products (e.g., wine). This image, combined with the available knowledge and infrastructure for exports as well as the advantage of the opposite production season compared with the major consumption markets in the northern hemisphere, enables relatively easy exports of organic products. The limitations to growth of the sector seem more to be at the production level than on the export level.

However, two important points should be highlighted. First, the current accreditation, certification and control system have not been recognized by the EC as being equivalent to their system. As a consequence, Chile is not included on the EC list of third countries. Therefore, Chile faces serious competition in exporting to the EC. Second, 70% of organic horticultural exports from Chile go to the United States, making Chile highly dependent on that market. An economic slowdown in the United States or a deterioration of the exchange rate between the US dollar and the Chilean peso is expected to strongly influence the development of the Chilean organic sector.

Support to exports. No direct support to organic exports is provided by the Chilean Government. However, indirect support exists through ProChile, which promotes Chilean exports, especially of non-traditional products, through support to companies to position themselves in foreign markets. In 1995, the Agricultural Export Fund was created by the Ministry of Agriculture. Its activities include assessments of (potential) export markets, contributions to seminars and support to companies in international trade fairs.

Situation in Brazil

Unfortunately, statistical databases are not available for the Brazilian organic fruit industry. However Brazil is the third largest world supplier of certified organic citrus, after Italy and the United States, with an estimated production of 100,000 metric tons in 2001.

Further increase is expected in Brazil since about 5,876 ha of groves were in conversion in 2002, which could potentially translate into an additional 100,000 tons of oranges (FAO, 2003).

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Apple Orchard Ecosystem Management: The Organic Apple Project at the Clarksville, MI, Horticultural Experiment Station

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The Clarksville Organic Apple Project is a long-term study of organic apple production. It is unique in that it is the first apple orchard in Michigan to be planted organic. Several faculty, growers, students and cooperators have been involved in implementing and managing the various complex aspects of running an organic farm, from conception as a new orchard to ensuring economical production. The overall goal of the project is to create an ecologically based organic production system.

Our ecological approach to organic ecosystem management is primarily functional ecology based. This means that we discern the function of each part of the ecosystem and detect what components are lacking or missing altogether. From this ecosystem analysis, we are able to decide whether the ecosystem is in working order. The concept of working order implies that the system is sustainable. Ground cover, arthropod population complexes, soil microbial communities and tree health are all considered in the ecology of the orchard. We believe that organic apple growers need to integrate a policy of creating a healthy ecosystem, in addition to their more traditional approach of “healthy soil, healthy food, healthy people.”

Representative of a working organic apple farm in Michigan, the design of the project includes four varieties of apple. The project includes three blocks, which employ three different ground cover control strategies, mulching, flame control and the Swiss sandwich system of tillage. Flanking these blocks are three diversity strips, which include diverse plantings of flowering plants designed to constantly provide nectar and refuge for predators and parasitoids.

Since starting the project, we are entering into the third season in which we will market a crop. The size and quality of the crop differ based on season-specific crop changes. We have been OMRI certified for both years of marketable fruit production and have experienced variety specific fruit quality and packout. We have also had a great deal of input from growers and have hosted several educational open houses at the Clarksville station.

Mites in Michigan Organic Apple Production

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Introduction

Mites are small to microscopic arthropods that are ubiquitous, occurring in every freshwater and terrestrial ecosystem. In an apple orchard, mites can occur in the ground cover, on the bark of the tree and in the canopy and fill a variety of niches, as fungivores and detritivores, to predators and herbivores. Late season blooms of herbivores can cause bronzing and early leaf fall, leading to problems with tree health in subsequent seasons.

Due to their small size and short generation time, mites are some of the quickest reactors to orchard disturbance. Everything from rain and wind to pesticide sprays and mowing can affect the levels of mites found in the canopy.

One of the goals of organic production is to decrease the impact of growing food on the environment. Using the current tools and systems, it is hard to assess the impact of organic agriculture. The most impactive production inputs also affect mite species' diversity and abundance. This fact has led us to use a suite of approximately 15 groups of mites to assess sustainability and ecological impact of apple production.

Objectives

Our main objective from this study was to develop a tool that used mites as an ecological indicator of sustainability in Michigan apples. This tool has been successfully developed, but we saw problems in organic production that need to be addressed in order to make this tool widely accepted.

Materials and Methods

Using an index developed by Dr. Whalon and Dr. Croft, we collect 100 leaf samples from orchards across an array of management practices, including abandoned, low input, conventional and organic. These samples are analyzed in the lab to ensure that all species are accounted for. The data from these samples are applied to the index, which puts each orchard on a scale of sustainability from -100 to 100.

Results

Most of the sites were pretty accurate to our prediction of sustainability, with Abandoned and Low Input being the most sustainable and Conventional being the least. Organic orchards, though, produced index values that indicated far less sustainability than we expected, closer to those of Conventional.

Discussion

Something very interesting is happening to mites in organics. Mite indices indicate that organic production is less sustainable than other forms. This is due in part to chemistries used in organic production that were never incorporated into earlier IPM systems. Also, mites are part of a complex ecosystem in which organic production is increasing sustainability, such as in the soil and groundcover. This is important to consider but should not mean that mites are overlooked in lieu of other factors.

Future work will focus on trying to understand better the interplay of mites and the organic ecosystem, which will include in field assays with organic chemistries.

Biological Control of Pear Psylla in Areawide Organic Insect Pest Management

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It is generally considered that predatory arthropods play an important role in controlling pests in orchards under organic pest management. Because the pesticides used are less disruptive, a greater density of natural enemies (NE) is expected. The NEs in turn assist the softer (and less effective) chemicals in pest control. And yet, there is little documentation by direct measurement in the field of levels of biological control in pear orchards. The development of areawide organic pest management offers an opportunity to study predation in a situation where biological control is most likely to be observed.

Baseline density and diversity of NEs, their spatial distribution, and levels of predation were examined in pear orchards under Organic, Soft, and Conventional pest management. NE densities were monitored at a large scale as part of the Peshastin Creek Areawide Organic Project and at a smaller scale on transects, and predation levels were monitored with sentinel prey.

The Peshastin Creek Areawide Organic Project compares pest and NE densities in pear orchards under Organic, Soft and Conventional insect pest management. NE populations were monitored weekly from late March into September in 2003 and 2004, and less frequently in 2002. Monitoring was conducted in 41 plots, from 1.5 to 10 acres each (5.5 acres on average). Beating trays were used to sample NEs at a rate of 25 trays per block.

Within the monitoring area nine sites were chosen, three in each management type, and in 2003 sampling transects crossing from the surrounding vegetation into the orchard were established. Management changes in 2004 resulted in four Soft and two Organic transects that year. The transects were 75 m long, situated perpendicular to the orchard edge, and extended 25 m into surrounding vegetation. Beating tray samples were taken at five locations per transect on a weekly to bi-weekly basis. All predatory (and potentially predaceous) insects were noted, and unknown insects were collected and brought to the lab pending identification.

Levels of potential predation were monitored with sentinel prey placed at some transects. Small cards (1.5 x 0.75 inches) holding flash-frozen *Ephestia kuehniella* eggs were exposed to predators at each of the five sampling points, three in the orchard canopy and two in the surrounding vegetation, with four replicates at each point. Eggs were monitored for mortality at 24, 48 and 72 hours of exposure. Data were analyzed after applying Schneider-Orelli's correction for control mortality.

Large scale sampling showed that in 2003 and 2004, although NE density was low, soft and organic orchards had significantly greater overall numbers than the conventional. In 2003 these differences did not develop until late summer. In 2004 the soft orchards supported more NEs than the conventional from the beginning of the season; organic levels rose above conventional in June.

Late season increases in NE numbers corresponded to increases in late-season pear psylla populations, suggesting that the low economic threshold for control of pear psylla limits NE density nearly as much as the use of non-selective pesticides.

Transect sampling revealed an uneven distribution of NEs, with consistently higher average densities in surrounding vegetation than within orchards. In 2003, the management types did not harbor levels of NEs significantly different from each other overall. In the surrounding vegetation, levels were highest in Organic and lowest in Conventional; in the orchard, Soft had higher levels than Conventional, with Organic intermediate. In 2004, Soft had more NEs overall than Conventional, with Organic intermediate. The vegetation showed no differences between treatments; in the orchard, levels in Soft were significantly higher than in the other treatments.

The NEs which comprised the communities along the transects tended to vary by habitat type. Spiders were the dominant NE in both habitats. The other most common NEs in the orchard were green lacewings, *Deraeocoris* and *Trechnites*, while the surrounding vegetation supported more ants, ladybird beetles, *Geocoris*, *Nabidae*, and snakeflies. NE densities did not vary consistently with year.

Results from the sentinel prey predation study were consistent with results from transect monitoring, tending to show greater predation in the surrounding vegetation. Levels of potential predation did not vary consistently by distance within a habitat type. Predation levels were relatively low in general.

Preliminary results indicate that although NE densities were low in all programs, NEs appear to be more numerous in orchards under Organic and Soft pest management. In all programs NE density was higher outside the orchards, as expected. The species composition also tended to be different inside and outside the orchards. Early data on predation levels suggest that they were affected by distance from untreated native vegetation. The study will be continued in 2005.

The Areawide Organic Project: Three Years in Peshastin Creek

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While biological control is the optimal approach to reducing insecticides in pear, it currently cannot control the major pests alone. For a long-term stable pest management program, we need a consistently effective program that coordinates chemical and biological control. These programs could be Soft or Organic.

Soft programs are intermediate between conventional pest management and Organic programs. They replace broad-spectrum pesticides with selective but not necessarily organic pesticides and aim to reduce overall pesticide inputs. Soft programs are safer for the environment than conventional programs, yet are more flexible than Organic programs.

Areawide Soft and Organic management encourages biological control by reducing the isolating effects of conventional management on natural enemy (NE) migration. Areawide control techniques also have the benefit of affecting pest populations on a large scale. Organic pear production may be highly appropriate for areawide pest management. The major pests, codling moth (CM) and pear psylla (PP), have management tactics available that make areawide organic management possible, including mating disruption for CM and kaolin (Surround) for PP.

This is a development project for an Areawide Organic Pest Management program for pears, in support of the farmer-based and -created Peshastin Creek Growers Association. The association adopted the mission of *increasing the use of environmentally friendly pest management techniques to enhance water and soil quality, improve worker safety, and reduce pesticide inputs*.

Preliminary work was done on the project in 2002, with work continuing in 2003 and 2004; work in the 2005 season has begun. The two main objectives of the project were 1) to replace conventional pest management practices with organic or soft areawide pest management and 2) to document the effects of three pest management programs on pest densities and crop damage, natural enemy densities, and costs of pest control.

The three programs were Organic, which used certified Organic management practices; Soft, which used organic pest management techniques when possible but also used IGRs and other selective pesticides; and Conventional, where organophosphates and other non-selective insecticides were used. Conventional orchards, not part of the Peshastin Creek Areawide Organic Project, were included for comparison. There were 56-61 (2003-2004) Conventional acres, 82-108 Soft acres and 91-58 Organic acres, sampled as 41 units of 1.5 to 10 acres.

Insect pest and NE populations were monitored weekly with beating trays, leaf samples and monitoring traps. Sampling for PP and NEs began in late March and CM monitoring began at the end of April; sampling for PP, CM, other pests and NEs continued until harvest (Sept). CM damage evaluations were conducted once during each generation. Orchard spray records were used to verify the management categories and calculate the costs of pesticides per acre of the different management types.

Pear psylla densities were lower in all three programs in 2003 and 2004, relative to 2002, although slightly higher in 2004 than in 2003. PP densities tended to be higher in the organic program than soft and conventional.

Pear rust mites (PRM) were problematic in Organic and Soft programs in 2003. There are no effective organic tactics for post-bloom control of PRM, and inadequate pre-bloom control led to severe economic damage in three Organic blocks. The lack of post-bloom interventions for PRM remains a limitation to selective programs. PRM was abundant in 2004 but caused little damage.

In 2003 codling moth pressure was high in several Soft and Organic blocks, but these programs were successful in bringing CM under control. CM densities were much reduced in 2004 and control was successful. In 2004 CM flight was significantly higher in the Conventional treatment than in the other treatments.

Natural enemy densities were higher in 2004 than in 2003. NEs increased in late-season in the Organic and Soft programs and stayed low in the Conventional program. Overall, the low levels suggest orchards managed for PP will never see large numbers of NEs; low PP damage thresholds may restrict the prey base to levels too low to sustain substantial predator populations.

Costs for pest control were similar for all programs, but Soft programs tend to be more expensive than Organic programs. Soft programs are also the most variable in cost, possibly due to their greater flexibility.

While pest densities can be slightly higher under Organic and Soft management, over a three-year period these programs have been successful in managing all pests. Initial results suggest chemical costs for these programs to be competitive with Conventional. Further analyses will determine the effects on fruit yield, quality and grower satisfaction. Results from these analyses as well as another year of study will provide better determination of the feasibility and benefits of implementing organic and soft programs on an areawide scale.

Rose and Strawberry Plantings Adjacent to Orchard to Enhance Leafroller Biological Control

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Objective—Establish simplified riparian habitats adjacent to orchards that support the overwintering of a key leafroller parasitoid and thereby improve biological control of leafrollers in pome fruits.

Introduction

This work evolved from two scientific discoveries: 1) that the exotic wasp, *Colpoclypeus florus,* had established in central Washington (Brunner 1996) and 2) that roses represent a host plant for the strawberry leafroller which in turn acts as an overwintering host for the wasp (Pfannenstiel as described Warner 1999). In 1999-2002 parasitism of leafrollers was measured in multiple orchards embedded in a 1000-hectare landscape mosaic in Wapato, Washington. Using field exposure of lab-reared larval *Pandemis pyrusana*, we found parasitism was very low in spring and modest in summer generations. Roughly half of the parasitism was caused by 2 tachinid flies and the remaining half by 3 wasp parasitoids. Parasitism by *C. florus* was found most reliably in orchard sites near riparian habitats and almost exclusively in summer. In late summer of 2000 we planted 4 gardens of wild rose, *Rosa woodsii*, next to orchards at sites distant from riparian habitats with a history of no parasitism by *C. florus*. Gardens were infested with the strawberry leafroller, *Ancylis comptana*, which subsequently became parasitized by *C. florus* in the fall of 2000. In the spring of 2001, sentinel *Pandemis* LR in both gardens and nearby apple orchards showed high parasitism by *C. florus* and much higher parasitism overall than observed in 1999-2000. Gardens acted as foci of *C. florus* parasitism in orchards through the 3 subsequent leafroller generations in 2001 and 2002. These manipulations demonstrate that the rose/strawberry leafroller community produces significant orchard leafroller parasitism in the spring when it is usually very low and that spring parasitism grows into even higher parasitism in the summer generation.

Methods

The work described above continues. Of the 4 original gardens, 3 remain and 25 new gardens have been planted in 2002-2003 by grower cooperators throughout Washington and Oregon. The hypothesis that these new gardens collectively test is whether provision of gardens and successful infestation of the gardens with the beneficial insect complex will result in elevated parasitism and control of leafrollers in nearby orchards. We hope with continued monitoring of each of the 28 gardens we will be able to provide a complete recommendation to growers on how to place, plant, and husband these multifloral rose gardens to control leafrollers biologically.

Results and Discussion

Results to date have been mixed. At some orchards the gardens have had little impact on parasitism of leafrollers in orchards. In many instances we suspect spray drift into gardens, sprays of the orchards themselves, or our inability to establish the strawberry leafroller in the gardens to account for low parasitism by *C. florus*. In one case, the Wenatchee Valley College Experimental Farm, we cannot implicate sprays or the absence of the strawberry leafroller, which is abundant, and suspect the placement of the garden in a ravine may inhibit wasp movement into the orchards above. At orchards near other gardens we see a significant impact, with high parasitism of leafrollers and reduced pesticide use for leafroller control. We hope with continued monitoring of each of the 28 gardens we will be able to provide a complete recommendation to growers on how to place, plant, and husband these multifloral rose gardens to control leafrollers biologically.

Finally, you might wonder how gardens adjacent to organic orchards have done compared to those near conventional orchards. There is no particular pattern except that our best gardens are all in a restricted area associated with conventional orchards. We think this has more to do with stewardship of the gardens than anything else. Specifically, chemical weed killing can be used to help establish the roses and is especially helpful if strawberries are also planted. Furthermore, organic blocks that we are working with do not fertilize through the irrigation line whereas some conventional orchards do. Thus, the irrigation to the garden also carries fertilizer that stimulates plant productivity and health. On the other side of the equation, and again relating to garden placement, we have found that some gardens that were planted very close to conventional blocks have suffered from spray drift and the strawberry leafroller has stayed at low abundance or not established. This can also happen at organic orchards using the natural product spinosad, in Entrust. If allowed to drift onto a garden, it will destroy the strawberry leafroller and adult parasitoids. Entrust, and a host of insecticides used by conventional growers, can kill the beneficial wasps when they are looking for leafrollers in the orchard. In contrast, codling moth granulosis virus and mating disruption are completely compatible with this habitat modification and biological control. In times of difficulty with leafrollers, organic growers should look to *Bt* (if it is warm enough for good activity) and Entrust (applied judiciously, i.e., to hotspots, in early to mid-April before parasitoids have come into orchards, or when the observed parasitism rate of the leafrollers in the orchard is low, etc.).

Please study the poster on our work and watch for a website hosted by the WSU Tree Fruit Research and Extension Center that describes how to place, plant, and foster a rose (and strawberry) garden, how to look for parasitism in the field, and how the 28 existing gardens are doing. The website will be a new link in the following location:
http://entomology.tfrec.wsu.edu/stableipm/

Conclusions

Creation of rose-strawberry habitats adjacent to orchards has increased parasitism of leafrollers in some cases and not in others. The approach is highly consistent with organic fruit production but a comprehensive recipe of how to accomplish success is not yet available. We hope the work to continue until 2007, supported by a Western Regional Sustainable Agricultural Research and Extension W-SARE grant, will allow us to provide this information to both the (organic and conventional) producer community.

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Biology, Migration, and Management of Western Flower Thrips in Apple Orchards

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Western flower thrips (WFT) is a direct pest of apple in Washington. It is a sporadic but locally injurious pest, with specific associations with large tracts of unmanaged habitat serving as a reservoir. The most conspicuous injury consists of an oviposition puncture, which leaves a small, rugose scar, and a series of white spots surrounding it, commonly known as pansy spot. While the susceptibility of cultivars has not been studied in detail, injury is most apparent on light-skinned cultivars such as 'Granny Smith'. WFT may attack other cultivars also, but the light-colored spots surrounding the oviposition scar color over on deeply colored sports, especially 'Delicious'. The rugose scar, however, remains. While the host range is known to be extensive, the ecology of WFT in Washington has been little studied. The contribution of extra-orchard habitat is generally assumed to be important, but has not been investigated in detail, nor has the role of weed host plants on the orchard floor. In addition, there is little information on the species complex that may attack apple, although multiple species have been implicated. The timing of damage or the stage-specific susceptibility of fruit to attack has been somewhat controversial, as has the relationship of adult populations to egg density and damage. Better understanding of these factors could provide more options for thrips management than currently exist.

Our objectives were 1) to determine the mobility of thrips in orchards and between orchards and near-orchard habitats; 2) to determine the efficacy of managing alternate hosts in the orchard ground cover during apple blossom for management of the resident WFT population; and 3) to determine the period of susceptibility of apple fruit to oviposition injury.

Distribution of thrips within orchards bordered by shrub-steppe habitat. Eight orchards with a history of thrips damage were selected from Monse to Moxee in the central fruit-growing region in Washington. Each orchard had an edge bordered by native vegetation. Samples were taken at six distances: border row (0), 30, 60, 100, 200, and 300 ft into the orchard from the native habitat at pink, open king bloom, full bloom, and at 100% petal fall. Twenty-five flower clusters at the appropriate phenological stage were collected at each location and time. Plant samples were washed in soapy water and thrips were extracted.

ELISA-protein marker mark-recapture techniques to determine inter-habitat migration. This experiment was conducted in a 0.7 acre block of mature 'Granny Smith' near Orondo, WA. The site is bordered by an extensive area of native vegetation on the east and north sides, with orchards on the remaining borders. A sample area of 0.5 acres of native habitat was marked adjacent to the orchard, extending approximately 50 m from the orchard border. On 9 April, the sample area in the native vegetation was sprayed to drip (handgun) with a 17.5% milk solution in water. The orchard floor (drive row and herbicide strips) was sprayed with solution of 10% egg whites in water. The treatments were repeated on 13 April. Two samples of apple flowers, dandelion flowers, and balsamroot flowers were taken post-spray. Insects were tested individually using ELISA for the presence of the protein marker.

Management of resident WFT populations by reducing alternative hosts within the orchard. Four orchards were selected with the following cultivars and locations: 'Braeburn' in Quincy, Pateros and Brewster and 'Granny Smith' in Bridgeport. Each orchard was approximately 5-10 acres. One-half of each block received regular herbicide treatments as well as spot treatments to reduce broadleaf weeds over time. The other half received herbicides only in the herbicide strips beneath the trees. Dandelions were counted in 10 1-m^2 areas once per month beginning in April. Plant tissue samples (apple and dandelion) were sampled periodically for the presence of thrips. Samples were washed with soapy water to dislodge adult and immature thrips. Specimens were slide-mounted for identification of WFT.

Phenology of thrips damage. At periodic intervals corresponding to the developmental stages of the apple bloom, 100 blossom clusters or 100 king fruit were sampled. The plant tissue was trimmed so that only the King bloom fruitlet or fruit remained, and this was stained with acid fuschin to reveal thrips eggs. The skin was placed between two glass microscope slides and pressed flat and observed with a dissecting microscope.

Distribution of thrips within orchards bordered by shrub-steppe habitat. Thrips populations changed significantly with greater distance away from the native habitat in samples taken at full bloom (P=0.0007) and in summed samples (P=0.007). Significant decreases occurred within 30 feet of the edge of the orchard at full bloom (P=0.035) and in summed samples (P=0.013). The same trend was found in fruit injury, which changed significantly as distance from the orchard increased (P=0.013). A significant decrease occurred within 30 feet of the border (P=0.018).

Mark-recapture techniques to determine inter-habitat migration. Of the thrips collected from apple flowers, 13.5% came from the native vegetation (milk marker), 1.7% came from the orchard floor (egg marker). Fifty percent of the thrips collected from dandelion flowers were marked with the egg protein, while only 24.3% of the thrips from balsamroot (native vegetation area) were marked with milk protein.

Management of resident WFT populations by reducing alternative hosts within the orchard. By the spring of 2004, all sites had fewer flowering dandelions in the treated block. No significant differences in thrips populations have been found in the apple trees between the two treatments in either year. Thrips fruit injury, while not different at any site in 2003, was significantly different in the Bridgeport orchard in 2004 (based on binomial 95% CI). The herbicide-treated block had 2.0% fruit damage and the weedy block had 5.8%.

Phenology of oviposition. The majority of thrips eggs were laid on king fruit shortly before 10.9 mm or 14 days after petal fall. This indicates a decidedly later spray timing than has been recommended (full bloom).

Conclusions

1. Populations of thrips in apple flowers were highest on the orchard border next to sagebrush steppe, indicating significant migration from dry uncultivated areas into the orchard. Results from 2004 indicate a large decrease in population within 30 feet of the border. The relationship is reflected in thrips damage to fruit.
2. The protein marking technique indicated the greatest contribution to thrips on apple flowers came from the native vegetation. This is a direct confirmation of the transect study which showed a strong border effect for thrips damage.
3. In the second year of comparisons between thrips populations in weedy and herbicide-treated blocks, very little reduction in thrips was measured. Only one site had significantly less fruit injury in the herbicide-treated block.
4. Sampling thrips eggs revealed very few eggs were laid in fruit during bloom. Most eggs were laid after petal fall. A Carzol timing trial indicated sprays were most effective (least amount of damage) a week after petal fall, after which they were ineffective. Full bloom control timing may not be optimal, and control measures improved by later timing.

Organic Management of Codling Moth with Pheromones, Entrust and CM Virus

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Case histories of organic control of codling moth, *Cydia pomonella* (L.), in two apple orchards using three organic technologies are presented to demonstrate their power and value in dealing with crises of pest control. The Carson-Frenchman Orchard is a 270-acre orchard struggling for several years to control codling moth using pheromones and mineral oil. In 2002 codling moth pressure was extreme with monitoring traps averaging 67 moths per trap over a three-week period in August. Damage from codling moth required hand removal of 158 bins of injured fruit prior to harvest, taking 989 man-hours. Exact crop losses at harvest in 2002 due to codling moth were not taken but estimates by experienced crop consultants put losses at 5%. Concerns about the excessive use of mineral oil on crop quality (size) and tree vigor, plus the availability of new pest control technologies, led to the development of an aggressive plan to address the severe codling moth problem. High carryover codling moth populations in 2003 were documented by average captures of 45 moths/trap over the first generation. Hand-applied pheromones, Isomate C-plus (Pacific Biocontrol), were applied at full rate. Entrust (DowAgrosciences), Cyd-X (Certis USA) and mineral oil were used against the first codling moth generation. At the end of the first generation fruit from the highest pressure blocks, based on history and moth captures, were sampled by timed visual examination. In these blocks fruit injury between 1-2% was detected but 90% of the injury were stings or unsuccessful larval entries. Codling moth captures in the second generation average only 3.6 moths/trap. No hand removal of codling moth injured fruit was needed during the season and injury at harvest was estimated to be less than 1%. The average cost of codling moth control in 2003 was high, $478 per acre. In 2004 pheromones again formed the basis for codling moth control with a reduced level of supplemental Entrust, Cyd-X and mineral oil applications. In 2004 only 72 codling moths were captured over the entire year, an average of 1.4 moths/trap. Fruit injury by codling moth was negligible and the average cost of codling moth control was much reduced compared to 2003.

The second case history involves a 5-acre apple orchard located in Wenatchee, WA. This orchard suffered from extremely high codling moth pressure and the grower estimated that 75% of the fruit was lost to activities of this pest in 2003. The entire orchard was treated with Isomate C-plus hand-applied dispensers at a rate of 400 per acre (full rate). Half of the orchard received supplemental controls of Entrust (first generation only), CM virus (Cyd-X) and mineral oil (Treatment #1) while the other half received only CM virus and mineral oil (Treatment #2). Two lure types were used to monitor codling moth in 2003, the MegaLure (Trécé Inc.) and the Combo lure (a mixture of pheromone and pear ester, Trécé, Inc.). The average capture in the MegaLure baited traps was 36 moths while the Combo lure baited traps captured an average of 101 moths. Both capture levels indicate extremely high pest pressure. At the end of the first codling moth generation injury in the Treatment #1 was about 3%, while the Treatment #2 had injury of about 15%. The effect of the different treatments was evaluated by cutting injured fruit and determining the percent of larvae that were alive. In treatment #1 only 3-8% of larvae were found alive, while in Treatment #2 40-44% of the larvae were alive. Fruit injury in the Treatment #1 had increased to about 7% by harvest (no Entrust was applied in the second generation), while Treatment #2 had fruit injury of 35% at harvest. It is clear that under high codling moth pressure the CM virus alone was unable to prevent a high level of damage. Other measures of treatment effects showed some of the impact on CM population. In late summer (August) cardboard bands were placed on trees in each treatment program. In Treatment #2 121 live CM larvae were detected in 50 bands while only 18 larvae were detected in bands placed in Treatment #1. Some of the larvae in bands may be killed by the CM virus but it appears that there will be a high carryover into 2004, especially in Treatment #2. The cost of materials used in Treatment #1 was $481/acre and in Treatment #2 it was $338/acre. It is very likely that, if one more Entrust application had been used in the second codling moth generation in treatment #1, the level of crop injury would have been greatly reduced. It may also be important to change the use strategy with CM virus, applying a lower rate at a more frequent retreatment interval. It will be important to follow the trend of these different treatment programs for at least one additional year in order to determine the relative long-term value of each.

Optimizing the Use of the Codling Moth Granulovirus: Effects of Application Rate and Frequency of Spraying on Control of Codling Moth Larvae in Pacific Northwest Apple Orchards

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Introduction

Codling moth (CM), *Cydia pomonella* L., continues to be the most devastating insect pest of apple in the Pacific Northwest. A goal of research is the development and adoption of alternative insecticides that are effective, safe to apply and leave no harmful residues on fruit. Recent work at YARL has focused on evaluating commercial formulations of the *C. pomonella* granulovirus (CpGV). CpGV targets larvae before or during initial entry into fruit and provides growers with an option for CM control that is safe to humans and CM natural enemies. In 2002, six weekly applications of the label rate (1 L/ha) of the Carpovirusine® formulation to individual trees in an experimental orchard provided control of first generation CM (larval mortality but not fruit damage) that was comparable to larvicidal oil and azinphosmethyl (Lacey et al., 2004). During 2003 several orchardists in the Pacific Northwest used the Cyd-X formulation at an operational scale with encouraging results (Arthurs and Lacey, 2004). However, the range of dosage and number of applications that provide effective control for various orchard conditions and codling moth pressures in the Pacific Northwest are unknown.

Objectives

1. Assess full-season virus programs adopting different application rates and spray intervals in an experimental orchard.
2. Compare different rates of virus applied weekly to Guthion in a conventionally managed orchard heavily infested with CM.

Methods

Experimental orchard trial. This study was conducted within a 1-acre plot of 6-year-old Delicious (Red Chief) at the USDA experimental orchard near Moxee, WA. Virus applications were made to individual trees using a Stihl SR420 backpack airblast sprayer with a large tarpaulin and a one-tree buffer used to confine treatments. Virus treatments (Cyd-X, Certis, USA) were applied in a 2-way factorial design with three levels for dose (1, 3 and 6 oz/acre) and application interval (7, 10 and 14 days). Dose rates covered the range labeled for use and intervals were based on persistence of treatments observed in 2003 (Arthurs and Lacey, 2004). Ten trees were randomly selected for each treatment and sprayed at a localized application volume of 100 gal/acre. The sticker Nufilm17 was included at 8 oz/acre and control trees were sprayed with Nufilm17 plus water. Initial virus treatments were made at 5% egg hatch and continued until ≈95% for both CM generations (Beers et al., 1993). CM injury was assessed from 50 fruit per tree at the end of the first and second generations. Damaged fruit was removed to the laboratory to assess both larval mortality and proportion of deep entries (> ¼ inch depth). Cardboard bands placed around trees captured surviving larvae.

Commercial orchard trial. This study was conducted within a 21-acre Delicious orchard near Zillah, WA. Virus applications were made using a conventional tractor-mounted 300 gal 'pull blast' sprayer. Individual ½-acre plots were marked out in complete randomized block design and treated with virus (Cyd-X, Certis USA) at three rates (1, 2 or 3 oz/acre). Five replicate blocks were sprayed at each dose @ 110 gal/acre plus NuFilm17 (8 oz/acre) weekly throughout the season, with initial treatments made at 5% egg hatch. Three additional untreated areas served as controls. For the assessments, fruit injury was periodically assessed from the central area of each plot and from adjacent areas treated with Guthion (azinphosmethyl). At the end of the first CM generation, 100 damaged fruit per plot were taken to the laboratory to assess larval mortality. Clear sticky 'interception traps' hung in the canopy at each plot's center were used to compare moth activity in the 2nd flight.

Results

Experimental orchard trial. While the virus applications did not reduce fruit damaged by CM, there were significantly fewer deep entries and surviving larvae among virus-treated fruit. The vast majority of damage was in the form of shallow stings (< ¼ inch) and larval mortality was consistently high (>80% in all treatments). There was a statistical trend of fewer deep entries and higher mortality rates of larvae associated with increasing doses and shorter application intervals. Rates of larval mortality were supported by the number of larvae captured in tree bands.

Commercial orchard trial. Six weekly applications of Cyd-X at 3 rates in the ½-acre plots resulted in less CM damage compared with untreated areas, but more compared with Guthion-treated areas. Most damage was observed higher in the canopy. Rates of CM mortality in virus-treated plots was high, similar to those observed in individual trees sprayed with equivalent rates of virus in the previous study. Data from interception traps showed far fewer moths in virus-treated and Guthion-treated plots compared with untreated areas. Despite this, the virus study was terminated before harvest when fruit damage approached 10%. The heavy infestation (trap counts averaged 70 moths/trap/week) and moths migrating from untreated areas contributed to the high damage level.

Discussion and Conclusions

Data from the experimental and commercial orchard provide information on the effectiveness of different virus programs against codling moth. The dosage and application frequency of virus that provides acceptable control (in many organic programs this will be a level at which a mating disruption program continues to be effective) will depend largely on the localized pressure of codling moth. Correlating moth counts from monitoring traps with the level of control required will allow growers to make informed decisions about including codling moth virus into their spray programs. Future work at YARL will also focus on optimizing the product persistence and larval uptake through formulation.

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Using Mulches to Improve the Efficacy and Persistence of Insect Specific Nematodes for Control of Overwintering Codling Moth

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Codling moth, *Cydia pomonella*, is the most serious insect pest of apple in the Pacific Northwest. In conventional orchards, the traditional method for controlling this pest is through the routine application of broad spectrum insecticides. Options for codling moth control for organic growers have been limited to methods such as oils, trapping, mating disruption, and manual removal of infested fruit. The recent registration of commercial formulations of the granulovirus of *C. pomonella* in the USA and their approval by the Organic Materials Review Institute (OMRI) expand the options for control of newly hatched larvae in organic orchards and provide a biological alternative for conventional growers. In addition, entomopathogenic nematodes (EPNs) targeted for overwintering stages of the moth offer the potential for a double-pronged strategy for controlling this pest. The overwintering stage of codling moth, cocooned larvae within hibernacula, is a difficult stage to kill using most conventional approaches. In the fall and winter, this stage represents the entire population and is virtually a captive audience if an effective means of control could be harnessed against it. The elimination or reduction of the codling moth at this time would provide significant protection to fruit early in the following growing season. EPNs are capable of controlling overwintering cocooned larvae of codling moth when moisture is maintained and temperatures are 60ºF and above. Preliminary research with nematodes and mulches indicates that nematodes will persist longer in moist mulch than on bare ground and provide extended control of cocooned codling larvae.

Since 1997 the USDA-ARS-Yakima Agricultural Research Laboratory has conducted several trials of EPNs to determine their most effective application strategy to control overwintering codling moth. We have found EPNs to be effective in controlling overwintering cocooned larvae of codling moth at application rates ranging from 0.4 to 1 billion infective juvenile nematodes (IJs) per acre when the habitat is kept moist for 6 to 8 hours and temperatures are 60ºF and above (Lacey et al., 2000; Unruh and Lacey, 2001). Maintenance of moisture after application of the nematodes using irrigation in orchards has been especially successful in trellised apple orchards and older pear orchards. Sustained moisture that was favorable for nematode survival is enhanced in orchards where mulch (shredded paper, hay, wood chips, or clover) is placed beneath trees. Mulching and crop residue have facilitated prolonged survival of EPNs in other cropping systems and enhanced their insect parasitic activity. In orchard agroecosystems mulching has been used for weed control and nutrient management. Our objectives in this studies were to develop evaluation methods for assessing impact of different mulch types on the larvicidal activity and persistence of insect parasitic nematodes, to evaluate EPNs in several mulch types using sentinel cocooned codling moth larvae, and to assess the persistence and recycling potential of candidate EPNs in apple agroecosystems with wood chip mulch.

Materials and Methods

Experimental orchard trials. Randomized and replicated study plots were set up within the Wenatchee Community College orchard in East Wenatchee. Applications of infective juveniles (IJs) of two commercially available species of nematodes, *Steinernema carpocapsae* and *S. feltiae,* were made using a backpack sprayer. Mulch treatments in the first trial (fall 2003) consisted of four ground cover types (shredded paper, clover, wood chips and hay) with conventionally maintained bare ground used as a non-mulched control. Untreated mulched plots were set up to monitor background mortality of both codling moth and non-targets. Five replicate plots of each mulch type were used for each nematode species and control. Sentinel cocooned larvae in cardboard strips were placed on the surface of the ground and in crevices in the ground beneath the mulch as well as in the bare ground plots. Prior to application of nematodes the irrigation was run for 30 min. After application of nematodes (1 billion infective nematodes/hectare= 0.4 billion/acre) the irrigation was turned on for 2 hours. Sentinels were collected 48 hours after spraying and incubated at 75ºF for one week before assessing mortality.

The second through fourth trials took place in the spring, summer and fall of 2004. Plots were mulched with wood chips only and five replicate plots were set up for each nematode species and untreated control. Sentinel larvae in cardboard strips were placed on the surface of the ground and covered with 2 cm of mulch. Five bare ground plots were also set up for each treatment and control with cocooned sentinel larvae placed on the surface of the ground. In the spring and fall, plots were treated with 0.4 billion nematodes/acre. In the fall trial, 1 billion nematodes/acre were applied. Sentinels were collected and incubated as before. During the fall trial, 3 days after application of nematodes, 30 diapausing larvae were released into each of 3 arenas/plot (30 cm in diameter). The arenas were constructed of stove pipe sunk into the soil of each plot (treated and controls, mulched and bare) prior to application of nematodes to minimize disturbance of the treated mulch. Five empty cardboard strips were placed 2.5 cm under the mulch of mulch plots or on the surface of bare soil plots to provide locations in which to spin cocoons. The cardboard strips in the bare plots and all of the mulch within the arenas of the mulched plots were retrieved 5 days after releasing larvae. Samples were kept at 50ºF until assessed for larval mortality. Using this approach we will be able to monitor the initial efficacy of nematode applications against codling moth *in situ* as well as the overall persistence and recycling potential against further larvae migrating into treated areas as the season progresses.

Results and Discussion

Both nematode species performed well against larvae that were placed in grooves within the soil. Nematode infection and mortality in control sentinels in grooves revealed the presence of native entomopathogenic nematodes (*Heterorhabditis* spp.). The on ground larvae in mulch were well controlled by both nematodes under the paper mulch, but variable responses were observed for the other mulches. *S. carpocapsae* was less effective under wood chips. *S. feltiae* performed better in plots with paper, wood chip and clover mulches than it did on bare ground. The same dosage of *S. feltiae* in the spring trials resulted in lower mortality of codling moth larvae in the mulch plots than in the fall of 2003 ostensibly due to lower temperatures. Mortality in mulch plots was significantly better than that in the bare ground plots. As in the fall 2003 trials, *S. carpocapsae* produced significantly lower mortality in codling moth larvae in mulch plots than *S. feltiae*.

Application of the higher concentrations of IJs in the fall of 2004 resulted in fair control of codling moth larvae by *S. feltiae* in the bare ground plots ostensibly due to its host-seeking ability. Control by *S. carpocapsae*, however, was considerably reduced. In the mulch plots, on the other hand, both EPN species produced significant higher mortality in codling moth larvae. Fairly low mortality (12-14%) due to both species of nematodes was observed in larvae that were added to mulched plots 3 days after application of IJs. Cocooned larvae tended to be clumped in groups of 4-5 within the arenas and infection of one larva per clump could ultimately result in the infection of nearby larvae due to recycling of IJs.

Conclusions

EPNs offer potential for control of overwintering cocooned larvae and mulches can extend the persistence and help to facilitate maintenance of moisture necessary for their activity. Control of the overwintering stage of codling moth will decrease the initial oviposition pressure the following spring. Nematodes used in combination with the codling moth virus and mating disruption have the potential for effective and conventional pesticide-free control of various stages of codling moth. Because of their specificity for insects, entomopathogens are ideal candidates for incorporation into IPM where their effects on natural enemies will be minimal as compared to most presently used chemical pesticides.

Apple Replant Disease Mitigation

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Apple replant disease (ARD) causes stunting of young trees and substantial losses in production over the lifetime of the orchard. Several causative agents have been implicated in the etiology of ARD including *Cylindrocarpon destructans*, *Phytophthora cactorum*, *Pythium* spp., *Rhizoctonia solani* and *Pratylenchus penetrans*. Growers planting orchards on "replant" sites have few options to avoid losses due to this disease complex which include fumigation (Chloropicrin, Telone, Metam Sodium, etc.), fallow, or treatment with bio-derived agents—all these options however can be expensive, give spotty results or not work at all. Organic apple production also poses different and more complex challenges to the root systems of young apple trees. The uncovering of genetic resistance to components of replant disease may give viable alternatives to curbing the effects of this disease, especially in an organic setting. Geneva apple rootstocks were bred using intensive disease screening methodology and diverse germplasm as the source of resistance. Preliminary studies indicate that some Geneva rootstocks show tolerance or resistance to ARD in New Zealand and NE United States. Knowledge of their performance in replant soils could give growers another viable option to maintain productivity in combination with available soil fumigation treatments.

The main objective of this study was to test the genetic tolerance of apple rootstocks to replant disease in different orchard settings including organic orchards.

Three new trials were planted in the spring of 2004 and more are planned for the spring of 2006. The location of these trials was picked on the basis of existing replant problems. The locations were Wapato (WA), Chelan (CH) and Naches (NA). The rootstock trials in WA and CH were planted in a split-plot fashion where one-half of the orchard was fumigated with Telone C-17 and the other half not fumigated – the CH site is in organic production whereas the NA and WA sites are conventional. The trial in NA was also planted as a split plot, however the orchard was split into three main plots treated with Telone C-17, Metam Sodium and unfumigated. The variety used for the WA and CH locations was Brookfield Gala and the variety used for the NA location was Honeycrisp. Several experimental and commercial rootstocks are being tested, among those are M.9, B.9 and M.26 standards, several Geneva rootstocks (G.41, G.935, G.11, G.16, 4214, 4210, 4814, 4213, 4003, 5087) and Supporter 1, 2 and 3. Trunk circumference data were taken at planting and in October 2004 and the mean amount of circumference growth was calculated for the rootstocks using a mixed model approach adapted to a split-plot experimental design. Another method was used to measure the site variation of each location: a mixed model analysis with the rootstock genotype as the main effect was used to calculate the residual for each sampling unit. That residual was then plotted in a contour plot based on the orchard map which shows the effectiveness of fumigation as well as the effectiveness of the tolerance of certain rootstocks.

It is too early to draw any conclusions on the experiments that were planted in the spring of 2004; however a preliminary look at the data has been able to indicate the effectiveness of the fumigation treatment and the initial response of the rootstock genotype to the replant variables. Visually, walking through the experimental orchard, one can see differences in the amount of shoot growth among different rootstocks. Fumigation had a positive effect on growth in all locations. At planting time the mean size of the trees for each rootstock genotype was different and that difference had a significant effect on the relative growth potential of that tree. Rootstocks G.11, G3041, G4214, Supporter 2 and M.9 Pajam 2 did not show a significant difference in growth in the fumigated and unfumigated treatments at the Wapato location. Rootstocks M.26, M.9 Nic 29 and Supporter 4 exhibited large differences in growth between fumigated and unfumigated treatments. Supporter 4 had the largest initial caliper of trees at the Wapato location. In the Chelan experiment G.16 and G.41 had the least differences between the fumigated and the unfumigated plots. Flower counts and fruit counts are being taken in spring of 2005.

It is evident from the early stages of this experiment that there are genetic differences in the response to replant disease among the rootstocks being tested. Unlike pre-plant treatments that may lose their effectiveness after only a few years, rootstocks that are genetically tolerant to this soilborne disease will last as long as the orchard. A combination of the best pre-plant soil treatment and the best rootstock tolerant to replant disease is the best strategy for the early success of the orchard. Discovering rootstocks that are adapted to organic culture practices will be extremely useful to apple growers.

Consideration of Plant-Microbe Interactions in the Application of Organic Amendments for Soilborne Disease Control

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Soil amendments have long been employed as a means to increase soil microbial activity, improve soil quality, control soilborne plant pathogens and pests, and enhance plant growth. Although the application of soil amendments in agricultural production systems is commonplace, our understanding of the mechanisms by which these enhance growth or suppress diseases, in many cases, remains elusive. As a result, there exists a significant challenge to develop a system in which the desired plant growth response is achieved on a consistent basis through application of organic residue amendments.

Brassicaceous soil amendments have been advocated as a viable option for the control of soilborne plant pathogens and parasites. As these tissues release biologically active glucosinolate hydrolysis products upon degradation, the commonly held hypothesis is that disease control is achieved in response to such amendments through the process categorized as "bio-fumigation." Findings from this program suggest an alternative or contributing mechanism of plant disease control resulting from the application of brassicaceous plant residues as a soil amendment. The goal of these studies is to determine whether relationships exist between changes in microbial community structure in response to brassicaceous seed meal amendments and resulting levels of soilborne disease control achieved in orchard ecosystems.

Proliferation of resident *Streptomyces* spp. populations was consistently observed in response to rape seed meal (RSM) soil amendments. In the orchard, these elevated populations were maintained over a two-year period. Associated with the population increase of this bacterial group was a significant reduction in the incidence of root infection by the fungal pathogen *Rhizoctonia solani*. In controlled experiments, it was found that RSM could elicit this disease control response in native soils but not in soils which had been pasteurized prior to RSM amendment, a finding which indicates the involvement of the resident soil microbial community in disease suppression. Likewise, RSM did not directly inhibit growth of the fungus, and RSM provided disease control in split-root assays where the pathogen and RSM were never directly in contact. In total, these findings indicate that control of *R. solani* is mediated by native soil microorganisms and functions through plant host defense responses. Nitric oxide (NO) is a known inducer of plant defense responses. The vast majority of *Streptomyces* spp. recovered from the rhizosphere of apples grown in RSM amended soil produce NO. In split-root assays, the same level of disease control obtained with RSM can be achieved with individual strains of *Streptomyces.* Further work is in progress to document the role of NO production by *Streptomyces* in the induction of plant host defense response and suppression of root infection by fungal pathogens of apple.

The use of RSM as an alternative to pre-plant soil fumigation for the control of apple replant disease (ARD) has been evaluated in field trials. Due to the proliferation of *Pythium* spp. in response to RSM amendment, the pre-plant incorporation of RSM is used in conjunction with a post-plant Ridomil soil drench. This treatment provide growth and yield of Gala/M.26, which was equivalent to that achieved in response to pre-plant soil fumigation at the Columbia View Research Orchard, a site lacking significant lesion nematode populations. At a second site that possessed high lesion nematode numbers, growth was significantly enhanced relative to the non-treated control but was inferior to that attained in fumigated soil. This response was directly associated with differential control of the lesion nematode.

Brassicaceous seed meals with enhanced activity toward lesion nematode and which do not stimulate *Pythium* spp. populations have been identified and evaluated in greenhouse trials. Such materials hold significant promise for use in the management of replant disease in organic production systems. Further evaluation will consider seed meal combinations to maximize disease control potential and elucidation of the mechanisms involved in the suppression of each element of the ARD pathogen complex by such soil amendments.

Bio-Nematicides for Management of Plant Parasitic Nematodes in Organic Apple Orchards

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Introduction. Washington State produces two-thirds of the US certified organic apples. However, the productivity of organic apple orchards can be improved if new tools become available to the growers to manage diseases, especially those caused by plant parasitic nematodes. Plant parasitic nematodes can cause economically important losses to fruit trees. Recently examined soil samples from several organic apple orchards contained high numbers of the lesion nematode, *Pratylenchus* spp. Numbers of the lesion nematode were above economic threshold and apple decline problems have been reported by the growers. Lesion nematodes penetrate tree roots and cause damage by feeding and migrating through the cortical tissue. In addition, interaction of lesion nematodes with other soilborne pathogens can increase injury to apple roots. Newly developed bio-nematicides have the potential to decrease plant parasitic nematodes without affecting soil microorganisms including beneficial free-living nematodes. These bio-nematicides can be used by both conventional and organic apple growers at a comparable cost to synthetic nematicides but without the environmental implications and human exposure risks. The following bio-nematicides (DiTera, NatureCur and SLS Enhanced Nematicide/Liquid Compost factor) were applied on trees.

Objectives. The objective of this project is to study the effect of three bio-nematicides (DiTera, NatureCur and Liquid Compost factor/SLS/CA Enhanced Nematicide) on plant parasitic nematodes in two organic apple orchards. In addition, we will evaluate the potential of all of the above bio-nematicides to enhance beneficial free-living nematodes in the soil. Beneficial free-living nematodes contribute to soil health. This study has the potential to provide organic apple growers with new tools to control plant parasitic nematodes.

Materials and Methods. This will be a 3-year field project on the efficacy of novel nematicides on organic apple orchards (Ray Fuller, Stormy Mountain Ranch, Chelan; Rene Garcia organic apple orchard, Naches). Field trials will be used to determine rates and efficacy of the bio-nematicides on the lesion nematode, on any other plant parasitic nematodes found in the orchard and on beneficial free-living nematodes. A randomized block design will consist of five trees per treatment and each treatment will be replicated three times. In Ray Fuller's farm three different rootstocks are used. Nematode data will be collected prior to applications, mid-season and at harvest. Nematodes will be extracted from the soil and from the feeder roots. In addition, fruit yield data and trunk diameter measurements will be collected. Three years of data are required to evaluate the effect of the bio-nematicides on nematodes.

Results. Data have been collected only from the first field season. Perennial crops respond slowly to bio-treatments. However, trends are showing that plants are responding positively to all bio-nematicide treatments.

Conclusions. Results from the first field season are very encouraging and they do show positive trends, but three-year data are needed for meaningful conclusions.

Alternative Pest Management Practices for Fruit

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Introduction

Several alternative control tactics were demonstrated or evaluated in apple and grapes in northwest Arkansas. Orchards treated with the codling moth (CM) granulosis virus (CpGV) had below 2% CM damage after 7-8 weekly applications (Polesny et al. 2000, Simon et al. 1999, Minarro and Dapena 2000). An organic spray program of *Bacillus thuringiensis* (*Bt*) provided control of OFM and CpGV controlled CM but both were less effective than Guthion (Rashid et al. 2001). Mating disruption of adults of internal Lepidoptera pests of apple, grapes and peach has been achieved by a variety of dispenser systems. The Exosex auto-confusion pheromone dispenser system is being developed by Exosect Ltd., UK, and has shown success in Europe against several Lepidopteran pests at a rate of only 10 dispensers/acre using 0.05 gm pheromone compared to 32 gm pheromone used in tie systems. An integrated program of mating disruption, postharvest fruit removal and tree cardboard banding controlled CM sufficiently to make organic apple production viable in British Columbia (Judd et al. 1997). These bands might be used to assess efficacy of certain spray programs. The last tactic of interest is the plum curculio (PC) trap tree baited with several packets of benzaldehyde (BA) and aggregation pheromone grandisoic acid (GA) that attracted more PC than did unbaited trees (Prokopy et al. 2003).

Objectives

1) To compare percent fruit damage by internal Lepidoptera larvae and the number of codling moth larvae overwintering in corrugated cardboard strips on apple trunks in a conventional block versus a nearly organic insecticide spray block.
2) To compare percent apple damage and number of larvae overwintering in cardboard strips on trunks in blocks with different ratios of CM to OFM that were sprayed with either a conventional spray program of Guthion versus softer insecticide formulations, e.g., bacteria-derived spinosad = Entrust, *Bt* = Javelin, and CpGV = Cyd-X, and the neonicotinoid = Calypso.
3) To continue evaluating Exosex mating disruption dispenser system against grape berry moth, codling moth, and oriental fruit moth.
4) To compare the percent fruit damage and number of PC in trees with and without bait packets.

Methods

In Berryville, AR, the conventional program had sprays of: Guthion on 31 May and 7 and 17 June; Intrepid on 24 May and 3 June and 6 and 17 July; Avaunt on 12, 17 and 26 July and 21 August; and 4 applications of 3M Sprayable OFM Pheromone at 3-week intervals from 24 June to 9 August. The organic program had sprays of: Cyd-X (3 oz/acre) applied on a weekly basis from 3 June on; Entrust on 3, 10 and 17 June and 2 July; Calypso on 12 and 17 July and 9 August; and Xentari (*Bt*) (2 lb/acre) on 24 June and 17 and 21 August. The percent damaged fruit from CM and OFM larvae in each block was recorded at harvest. In two rows of the conventional block (106 trees) and 114 trees in the organic block had 6-inch wide corrugated cardboard strips stapled around each trunk on 8 September. These strips were removed on 2 December and we recorded the number of CM larvae per strip.

An abandoned block of 'Golden Delicious' apples in Springdale, AR, was arranged as one tree plots (5 replicates) in a randomized complete block design with conventional treatments of Guthion (azinphosmethyl) and Calypso (thiacloprid) applied on 17 and 26 May, 24 June and 8 July, whereas organic formulations of Cyd-X, Javelin (*Bt*), and Spinosad (Entrust) were applied on 17 to 19, 26 May for 1st generation of CM and OFM and 24 June, 1 and 8 July for 2nd generation of CM. Sprays in the same experimental design were applied weekly from 24 August to 15 September in apple blocks in Berryville and Fayetteville, AR. Percent fruit with stings or frass or shallow tunneling by CM or OFM larvae was determined by inspecting 50 fruit per tree after each generation.

An abandoned 7-acre ‘Jonathan’ apple block had a total of 1498 OFM/trap caught from 31 March to 11 May. This extremely high first flight was knocked down by having the grower apply three Guthion sprays on 22 April, 2 and 12 May in preparation for the MD study. Ten Exosex-OFM dispensers/acre were placed in upper tree canopy on 14 May and 10 Exosex-CM dispensers/acre were placed on 2 June. We set out 10 Exosex-GBM dispensers per acre on 13 April (just before adult flight) around the perimeter of a 1.4-acre abandoned ‘Concord’ and ‘Fredonia’ grape vineyard and uniformly spaced the same number throughout the vineyard on 7 June (just before the 2nd generation flight). Damage was assessed after each generation in both the Exosex-treated vineyard and a conventional vineyard about 600 ft to the west managed with two insecticide sprays for each generation of GBM.

Every fifth tree along the forested edge of one apple block (5 replicates) was baited with 8 BA and 2 GA packets and had a gray pyramid trap tethered to the trunk on 1 April. Biweekly counts of adult PC per trap were made until early June when 100 fruit per each of 25 trees were inspected for PC damage.

Results

Similar fruit damage occurred in the conventional and organic apple blocks in Berryville, AR. This conventional block had 1.5% fruit damage at harvest compared to the organic block that had 6.7 and 12% frass damaged apples, respectively, on 8 and 15 September. However, the frass damage in the organic block was associated with larval tunneling < 1/8 inch deep but no live larvae. Cardboard strips in place on apple trunks from 8 September to 2 December in the conventional block had 1.83 live and 0.87 dead codling moth larvae per strip whereas the organic block had only 0.24 live and 0.25 dead codling moth larvae per strip.

In Springdale, AR, on 11 June, there was significantly greater fruit damage in the check, Javelin and Cyd-X treatments than in the trees treated with Guthion, Calypso and Entrust. By 16 July, only Cyd-X had similar damage to that of the check; all others had significantly less damage in a block where there were more OFM (0.1 ratio of 86.5 CM to 779 OFM per trap). The sprays evaluated in August in Berryville, AR, had similar damage in trees of the untreated check and Javelin (*Bt*) alone and both had significantly more fruit damage than did the Cyd-X or Cyd-X + Javelin (*Bt*) treatments. The Berryville orchard had more CM than OFM (4.3 ratio of 55 CM to 12 OFM). In Berryville, cardboard strips on trunks from 8 September to 2 December collected significantly more internal feeding Lepidoptera larvae in the check trees than in trees sprayed with Cyd-X, Javelin (*Bt*) or the mixture.

The grape vineyard block with 2 placements of 10 Exosex-GBM dispensers/acre had 2- to 3-fold more damage (3.5, 4.1 and 9.5%) than did the conventional block (1.8, 1.9 and 3.1%), respectively, on 15 June, 7 July, and 27 July. The apple block with placement of 10 Exosex-OFM dispensers/acre on 14 May and 10 Exosex-CM dispensers/acre on 2 June showed fruit damage on 30 May was 0.04% in the Exosex block and 4.3% in the abandoned orchard and on 16 July was 4.6% in the Exosex block and 5.4% in the abandoned orchard. The resulting fruit damage on 30 May was 0.04% in the Exosex treatment and 4.3% in the abandoned orchard and on 16 July was 4.6% in the Exosex treatment and 5.4% in the abandoned orchard.

The baited apple trees had significantly more PC fruit damage (17%) than recorded in unbaited trees with pyramid traps (5.2%) and trees without a pyramid trap or baits (2.2%).

Conclusions

In this study, the conventionally sprayed apple block had less fruit damage but more overwintering larvae in cardboard strips on the trunks than did the organic block. The population was predominantly OFM in Springdale, AR, where Cyd-X performed poorly and predominantly CM in Berryville where Cyd-X did well. The Exosex auto-confusion pheromone dispensers did not result in adequate control of CM and OFM in apples or GBM in grapes. In 2005, we hope to investigate the use of DA traps in pheromone-treated blocks and continue to use cardboard strips on trunks to compare conventional and organic blocks for end of generation counts of CM and estimate the overwintering population. We also will have additional sites to demonstrate PC trap trees in the orchard border baited with benzaldehyde and grandisoic acid.

Organic Quarantine Treatments for Pome and Stonefruits Using CATTS (Controlled Atmosphere/Temperature Treatment System)

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Controlled Atmosphere/Temperature Treatment System (CATTS) has been used to develop quarantine treatments for apples, winter and summer pears, peaches, nectarines, and sweet cherries against the internal feeding pests codling moth, *Cydia pomonella*; oriental fruit moth, *Grapholita molesta*; western cherry fruit fly, *Rhagoletis indifferens*; apple maggot, *Rhagoletis pomonella*; and plum curculio, *Contrachelus nenuphar*. These treatments were developed to optimize the differences in plant and insect physiological responses to high temperature stress.

We have demonstrated that, by controlling the rate of heating, fruit quality can be maintained while the CATTS treatment provides control of internal feeding quarantine pests. Fruit firmness is maintained during storage for apples, pears, peaches and nectarines. This is due to the effects of heat on the ripening enzymes. Postharvest disorders such as superficial storage scald in apples and mealiness in nectarines and peaches are controlled by CATTS treatments. Disorders in apples such as sunburn, bitter pit, and black heart disorder are exacerbated by the treatment, leading to cullage prior to packing and storage.

There are currently laboratory-scale (able to treat 120 lbs of product), half ton, and 2 ton commercial CATTS units. Efficacy tests (5,000 killed with zero survivors) have been performed on codling moth and western cherry fruit fly in sweet cherries using two CATTS treatments in the lab scale CATTS unit. Efficacy tests against oriental fruit moth and confirmatory tests (30,000 killed with zero survivors) against codling moth in peaches and nectarines have been performed using two CATTS treatments in the lab-scale CATTS unit. Efficacy tests against codling moth and oriental fruit moth have been performed on apples using the 2 ton commercial CATTS unit. Confirmatory tests against codling moth in apples have been performed using the laboratory-scale CATTS unit. These treatments will help the organic fruit industry in providing a rapid, direct postharvest quarantine treatment with little effect on commodity quality.

Challenges and Opportunities for Organic Apple Production in Iowa

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Consumer demand for organically raised fruits and vegetables has increased since the implementation of the USDA-NOP (National Organic Program) seal in 2002 (OTA, 2004). Organic fruit growers in the arid western U.S. have a substantial advantage over Midwestern orchards because of low humidity and low disease pressure. The best system for organic apple production in the Midwest includes the use of apple cultivars that are resistant to the disease apple scab [*Venturia inaequalis* (Cooke)] (Domoto et al., 1999; Friedrich et al., 2003). With the development of disease-tolerant cultivars for apple scab management, organic apple production in the Midwest has expanded beyond backyard production to commercial operations, although many challenges remain. One of the most challenging aspects of organic apple production in the Midwest is insect pest management. Because a systems approach in regulating pest species is prescribed in NOP rules (USDA-NOP, 2005), integrated approaches, including mechanical, cultural, and biological control methods, are utilized in certified organic apple systems to control the most destructive insect pests: codling moth [*Cydia pomonella* (L.)], plum curculio [*Conotrachelus nenuphar* (Herbst)], obliquebanded leafroller [*Choristoneura rosaceana* (Harris)], oriental fruit moth [*Grapholita molesta* (Busck)] and apple maggot [*Rhagoletis pomonella* (Walsh)] (Phillips, 1998).

Providing food and nesting sources for beneficial insects is included in organic pest management in orchards. Physically dislodging plum curculio from tree limbs was a popular control method in organic orchards prior to the introduction of kaolin particle film. Coloring bags were developed to aid color formation in Fuji cultivars but have also been employed as a labor-intensive method of protection against insect pests. Mating disruption pheromone technology is considered an essential component of codling moth management in organic apple orchards (Swezey et al., 2000). In order to be effective, however, pheromone dispensers must be placed throughout the orchard, thus limiting comparisons with a “control” block in any organic on-farm trial. Proximity to wooded areas with wild apple, plum or hawthorn species harboring key pests is also considered an impediment to organic management. Comparisons with conventional orchards are difficult due to the dissimilarity of apple cultivars, with organic orchards planting scab-resistant cultivars and conventional orchards managing scab through a synthetic spray program.

A trial was conducted in 2003–2004 at the Wills Family Farm in Adel, Iowa, where scab-tolerant apple cultivars are grown for on-farm sales, cider and for processing into baked goods. The objective of this on-farm demonstration was to compare apple cultivar susceptibility to plum curculio, codling moth and apple diseases under an intensive organic spray program. An integrated pest management program, certified through Organic Crop Improvement Association, was followed in this trial. There were 108 apple trees in the demonstration, with 10 trees of each of three scab-resistant cultivars (‘Enterprise’, ‘Liberty’, and ‘Gold Rush’ in 2003; ‘Redfree’ in place of ‘Gold Rush’ in 2004) utilized as sampling units for insect, disease and yield ratings. A typical Midwestern organic apple spray schedule for management of codling moth, plum curculio and leafroller was employed. As previously described, the entire orchard was treated because of the problem of providing a refugia in untreated control blocks. The spray program in 2003 included Surround® WP (at 56 kg ha^{-1}) on 16, 21 and 29 May; a *Bacillus thuringiensis* spray (Dipel™, Abbott Inc. Chicago, IL) on 16, 21, 29 May; 10 and 26 June; and 2 and 11 August at 1.12 kg ha^{-1}. An organically approved spinosad formulation, Entrust™ (Dow

Chemical, Midland, MI) was sprayed on 16 and 29 May; 10 June; and 2 and 11 August at 146 mL ha^{-1}, and on 26 June at 292 mL ha^{-1}. No fungicides were applied. Three codling moth traps were placed in the orchard to monitor insect populations. Cards were collected and replaced every month. Insect and disease data were taken mid-July by randomly inspecting five leaves from five trees in each plot. Prior to harvest, fruits were inspected (five apples on five trees in each plot) for insect and disease damage.

Harvest data included weight of 20 apples per tree (200 per cultivar) and percent damaged apples from codling moth and plum curculio feeding. 'Liberty' was harvested on 26 September; 'Enterprise' on 4 October; and 'Gold Rush' on 20 October 2003. 'Redfree' was harvested on 9 August 2004; 'Liberty' was harvested on 6 October 2004; and 'Enterprise' was harvested from 2 to 23 October 2004. Apples were not produced on 'Gold Rush' trees in 2004. All data were subjected to analysis of variance and mean separation.

In 2003, we found 'Gold Rush' apples had significantly more quince rust infection compared to 'Enterprise' and 'Liberty' apples. 'Enterprise' also had a higher individual average fruit weight at 0.23 kg compared to an average of 0.15 in 'Gold Rush' and 'Liberty'. There were no significant differences among cultivars in plum curculio and codling moth damage, despite a trend towards lower codling moth damage in 'Gold Rush' and lower plum curculio damage in 'Enterprise'.

In 2004, leaves from the 'Enterprise' trees had significantly more powdery mildew than the other cultivars (24% occurrence compared with an average of 3% in the other cultivars). There was a significantly higher occurrence of spider mites on the 'Liberty' leaves compared with the 'Gold Rush' and 'Redfree' leaves. 'Gold Rush' leaves again had a significantly greater incidence of cedar apple rust than the other cultivars (80%) while 'Redfree' leaves were intermediate (13%) and 'Enterprise' and 'Liberty' leaves showed no cedar apple rust symptoms. 'Redfree' leaves had a significantly higher percentage of damage due to scab compared with the other cultivars (9% compared with an average of 1%). For the second year, 'Enterprise' weight was significantly greater than 'Liberty' and 'Redfree' apples. There were no significant differences among cultivars in fruit damaged due to plum curculio or codling moth. Codling moth damage ranged from 3.0 to 5.6% in 'Enterprise' while plum curculio damage ranged from 3.1 to 10.0%.

Codling moth and plum curculio damage below 10% is considered competitive for organic apple orchards where a 50–100% price premium can be obtained for direct-marketed organic apples. Similar to results demonstrated by Reganold et al. (2001), organic apple production systems can be obtained with improved profits, soil quality, taste and texture if certified organic techniques and intensive monitoring and treatment programs are in place.

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Organic Orchards in the Northeast: Progress, Practices and Problems

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Although there is strong consumer demand for organic produce in the Northeast, the acreage of certified organic orchards in this region has lagged far behind that on the west coast. For this report we reviewed the current situation and trends in certified organic tree-fruit production in the northeastern USA, including Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Vermont, and Rhode Island. In gathering this information, we used farm profiles on the websites of organic certifying agencies in each state, telephone interviews, farm visits, and a brief survey that was sent to all certified orchards in each state with available e-mail addresses. This survey asked growers how many acres of organic fruit they managed, what their greatest challenges and rewards were in organic production, how much of their farm income was derived from organic tree fruits, and which organic research topics should be high priorities in the Northeast. The rate of e-mail survey responses was low, so we followed up with telephone interviews.

Reliable information on farm profiles, acreage, and practices was not easily gleaned from farm or certifying agency websites or other internet-based sources. All of the Northeast organic certifying agencies have websites listing certified organic enterprises, but on many of these it was not possible to distinguish actual farmers from large or small retailers who buy organic produce in or out of state and resell it to the public. These mixed certification listings put actual growers and direct marketers at somewhat of a disadvantage in attracting interested consumers to their farms or direct outlets and made it necessary for us to contact most of the listed sources directly to confirm their role in the organic food network.

After considerable searching, the profile that emerged for organic orchards in the Northeast differs qualitatively and quantitatively from that in other regions. As a portion of all certified organic farms or of all commercial orchards, there are relatively few organic fruit growers in the east. For example, only 13 of 333 sources of organic produce in Vermont grew tree fruits, and only one of those 13 orchards had more than a few acres of trees under organic management. In New York, which has about 600 commercial orchards on 60,000 acres, only 20 of 312 certified organic farms grew tree fruit, and only three of those 20 had more than a few acres of orchard. Some states apparently have no commercial organic orchards (Rhode Island). Most of the organic orchards in the Northeast are on diversified farms that also produce vegetables, herbs, flowers, maple syrup, dairy products, eggs, meat, and other products. Many of these fruit farms also sell value-added products such as sweet or hard cider and fruit preserves. Almost all Northeast organic orchards market directly through farmstands or roadside markets, farmers' markets, CSAs, or restaurants (on and off farm). Many also sell fruit through locally based cooperative markets or “food coops.” Very few organic orchards in the Northeast wholesale their fruit through packing houses or juice processors, and the organic fruit on supermarket shelves in the Northeast is almost always from out-of-state sources.

For apples, surprisingly few Northeast organic growers rely upon disease-resistant varieties such as Liberty, Sansa, or GoldRush for their main production; most are growing standard varieties such as McIntosh, Macoun, Jonagold, Gala, and Northern Spy that require frequent applications of copper and sulfur-based fungicides in humid climates. An increasing number of organic growers also feature “antique” apples such as Golden Russet, Roxbury Russet, or Ashmead’s Kernal for which local demand and market prices have been strong.

There has been increased research devoted to organic tree-fruit production systems in the Northeast recently, fueled by greater funding and grower demands for research-based production recommendations. The recent availability of kaolin clay and spinosad insecticides and spray oil/lime sulfur fruit thinning techniques have made it more practical to grow tree-fruit organically with acceptable levels of pest damage and fruit size at harvest in the Northeast. Long-term studies are underway at Cornell University, comparing organic and IFP (Integrated Fruit Production, the main "green" or "ecological" farm certification program in Europe and New Zealand) systems in an established orchard of Liberty apple on M.9 rootstocks. In the first (transitional) year of this study, pest-damage culls of fruit at harvest were similar at 6.6% in organic vs. 4.5% in IFP plots, and harvestable yields were excellent (about 950 bu/acre, well above the state average) in both systems (Vollmer, 2005). Total costs for weed/pest control and fruit thinning (during a very wet summer when multiple kaolin clay applications were necessary) were $2543 per acre in organic vs. $1057 in IFP. The estimated market value of fruit, based upon grading into box-count sizes and a 35% price differential for the organic apples, was slightly higher in the Organic ($10,652 per acre) vs. the IFP ($8792) system. This experiment will be continued for five years, through the transitional certification period. Evaluations will include soil/tree/pest complex responses to each system, economic analyses, postharvest tests of fruit quality, nutritional (elemental content) and nutriceutical (antioxidant activity and total phenolics) attributes, and consumer panel evaluations of fruit flavor and appearance.

The situation for organic tree fruit growers in the Northeast is evolving in response to local and national market forces, new technologies for pest management, consumer demand, and producer/consumer interest in more sustainable farming practices. Organic farms with orchards in this region are smaller, more diversified, and more closely linked to their local communities and consumers than in many other parts of the USA. Ecotourism, diversification and on-farm marketing are an integral aspect of most Northeast organic orchards and will be essential for the long-term survival of organic orchards in this region where formidable pest complex and production costs create disadvantages compared with irrigated orchards in semi-desert regions.

University of Arkansas Agriculture Professionals' Perceptions Toward Sustainable Agriculture.

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Introduction

Interest in and conversion to sustainable agriculture practices, such as organic production, integrated pest management or increasing biodiversity, have been increasing recently across the United States. In order to meet the needs of producers and sustain the emerging industries, university researchers and educators must adapt their programs to reflect this change towards sustainable and ecologically based agriculture practices. A potential barrier to program development may be belief and perceptions of agriculture faculty regarding organic, sustainable, and ecological agriculture systems. However, there is limited information on this issue. Few surveys have examined sustainable agriculture perceptions among university agriculture professionals.

Objectives

This research was conducted to identify perceptions of UA agriculture faculty towards sustainable agriculture (SA) and organic agriculture by assessing the:

1) opinions of faculty on SA needs at the UA,
2) incentives and factors influencing UA agriculture faculty involvement in SA,
3) current educational programs and research projects pertaining to SA at UA.

Methods

A 78-question survey, cover letter, and reply envelope were distributed to 226 UA College of Agriculture faculty on February 9, 2004, via campus mail and the US Postal Service for off-campus faculty. The same survey was also delivered on-line and both forms of the survey contained instructions to complete only one form. A follow-up email reminder and mailing were sent out 1 week after the initial mailing and the survey closed on February 20, 2004.

The survey, developed in 4 sections, was developed by a group of agriculture scientists from the UA and National Center for Appropriate Technology and pre-tested prior to distribution. Section I asked faculty to rate their personal interest and professional interest, on a Likert scale of 1-5, on various subjects relevant to SA. They were also asked the percentage of their research directed in the same subject areas. Section II asked faculty to rate incentives for involvement with interdisciplinary work within the contexts of SA. Section III asked faculty to rate their feelings, on a Likert scale of 1-5, on statements pertaining to sustainable and organic agriculture at UA. Section IV asked various questions including demographics, department, and percentage of research in applied and basic research and sources of funding.

Results and Discussion

Ninety-eight surveys returned for a 43% return rate. For statistical purposes, departments were combined into larger discipline areas: "Animal Sciences" (AS), "Crop Sciences" (CS), "Human Sciences" (HS), and "Other" (OTH).

Perceptions. There was generally more personal interest than professional in specific categories under SA, generating low Kappa statistics. A moderate level of agreement between personal and professional interest in SA was determined (Kappa = 0.45). CS had the highest resource contributions to SA in terms of number of faculty and percentage of research. Twentynine percent of faculty reported no research efforts in SA, 44% reported 1-40% of their research in SA, and 27% reported 41-100% of their research is in SA. Of those who reported 41-100% research in SA, 80% were from CS. In organic agriculture 23% and 2% of faculty reported research in 1-40% and 41-100% research, respectively. All of these faculty were in CS.

There is agreement among faculty to develop a "center for sustainable agriculture" (51%) and to increase both "sustainable research" (67%) and "organic research" (43%) at UA.

Incentives for interdisciplinary work. Service to farmers, potential for success, potential for discovery and financial support for research and development were highly important incentives for involvement in interdisciplinary work. Tenure attainment, salary improvement, authorship, prestige, securing grad students, and recognition were less important incentives.

***Current status of SA activities**.* Several faculty are presently working, at some level, in various topics under the SA umbrella (71%). There is the potential to increase the mode by involving more faculty in multidisciplinary projects.

SA needs at UA. It was also found that there is a need to increase education programs about SA for both UA agriculture professionals (42%) and producers (38%). Although there was interest in developing undergraduate and graduate programs in SA (36%), opinions were broad with 33% disagreeing and 30% having no opinion.

Conclusions

Through this research, we have determined there is substantial interest in SA research and education programs among faculty at UA. There is also a need for educational programs for producers, students and agriculture professionals. Although there is some work being conducted in organic and SA at UA, the potential exists to increase this level through multidisciplinary research and education projects, especially considering the importance of multidisciplinary work (87% agreement) and the work being conducted within the SA rubric. The survey findings will provide a foundation for directing and developing agriculture research and education programs for fruit, vegetable, row crops and animal/poultry production and in support of other horticulture and agriculture industries.

The Southern Organic Fruit Production Initiative

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Introduction

Southern organic fruit production is limited by a lack of regionally appropriate, scale-neutral and market-focused research and technology. There has been limited research, outreach and cooperation among universities on organic fruit crops in the southern region. Organic research and outreach activities should be based on stakeholder input and focus on the most limiting areas of the organic system to allow southern producers to receive the economic and environmental benefits that organic production can provide. With funding from USDA-SARE and USDA-SRIPMC, researchers at the University of Arkansas have collaborated with scientists, extension specialists, growers, and representatives of the organic industries and allied services in Arkansas, Georgia, Kentucky, North Carolina, South Carolina and Tennessee to initiate an investigation of organic fruit production in the southern U.S. in order to support and expand production.

This project was developed to create a Southern Region Organic Fruit Research Working Group to:

1) Assess the state of organic fruit production in the South,
2) Identify interest, obstacles and management issues in organic production and organic information needs through stakeholder and participant focus groups,
3) Develop innovative partnerships of research, extension, industry, tree fruit growers and local farmers' markets,
4) Develop an organic fruit research initiative to investigate and develop new organic fruit management techniques.

Methods

This project was designed as a two-step process which first conducted in-state focus group meetings in Arkansas, Georgia, Tennessee, North Carolina, South Carolina, and Kentucky with producers, industry, market organizations, research scientists, and extension workers to identify significant barriers, research questions, and market opportunities for organic fruit crops in each state. The second step was a region-wide conference by the project collaborators from the Universities of Arkansas, Georgia, Tennessee, North Carolina State University, Clemson, Kentucky State, NCAT-ATTRA and Gerber Products to form a Southern Region Organic Fruit Working Group (SROFWG) to focus on key region-wide barriers to organic fruit production, to prioritize research questions, and to determine appropriate markets and marketing strategies for southern organic fruit crops.

Results and Discussion

Focus group findings. Similar findings were reported across the state focus meetings. There are very few organic fruit producers throughout the South, although there is interest in certified organic production and organic production methods. Most of the focus group grower participants were not organic producers but rather conventional producers who were interested in organic production. Producers cited many research and information limitations and needs comprised of economic and production information on soils, diseases and pests; development and economics of small-scale, local processing facilities; and demographics of local consumers for reaching and expanding local markets.

Priorities identified by project collaborators*.*

1. Develop projects with traditional crops for small, diversified farms using organic production practices and connect with university courses to create opportunities for undergraduate research projects. Establish a grower advisory committee to build bridges and establish relationships, to help develop case studies for the region and to give input on research projects.
2. Develop regional organic crop production guides for apples, peaches, blueberries, and blackberries. Develop information from research on organic production systems in the South but also adapt existing information from other areas of the country or from conventional methods into forms acceptable to organic producers.
3. Conduct consumer and producer surveys to evaluate the “power of the industry”: consumer dollar spent on local and organic food, number of producers, certified and otherwise, and interest in conversion to organic.
4. Formalize recognition as a working group through a SERA (Southern Extension Research Activity) project to facilitate administration support and increase funding opportunities for organic research.
5. Unify collaborating universities by designating organic land on an Experiment Station, in each state, for demonstrations and classroom teaching and also to create an opportunity for cooperation on regional organic research projects.

Conclusion

The southern region organic fruit production initiative successfully brought together scientists, producers and other members of the organic industry to identify needs, barriers and advantages to organic fruit production in the southern region. Focus group meetings were effective in assessing the status of organic fruit production in the South and gaining information on producer needs. Sufficient information was generated to begin working on prioritized needs. Additional meetings, discussions and surveys are needed to highlight specific problems. As a result of this project, linkages have been established and will continue to grow between the scientific community and the organic industry to improve the effectiveness and efficiency of existing organic fruit production in the South.

Phytoavailability of Zinc in Commercial Zinc Spray Products Applied to Apple

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Zinc (Zn) deficiency is widespread in deciduous tree fruit orchards in the western states. It occurs naturally and visually is expressed as little leaf, rosetting, leaf chlorosis, blind wood, and shoot dieback. Zinc deficiency can severely reduce the amount of marketable fruit in affected orchards because of its direct influence on the amount of viable fruiting wood. Washington State University (WSU) recommends that Zn be applied annually as a maintenance spray to prevent development of the deficiency. Current recommendations rely heavily on dormant to delayed-dormant sprays of high rates of Zn either as Zn sulfate ($ZnSO_4$) or basic Zn sulfate ($ZnO \cdot ZnSO_4$), based mainly on the historical success of these practices. The recommendation for postbloom Zn sprays for bearing apple trees does not mention any Zn products by brand name or specific composition, referring ambiguously to “zinc chelate or organic complex” applied according to the manufacturer’s label.

There is an additional compelling reason to examine alternatives to current Zn recommendations. In Washington orchards, high rates of fertilizer Zn often are applied to compensate for low phytoavailability. Up to 15 lb Zn per acre per year may be applied in some circumstances. Use of such high Zn rates is not a sustainable practice because of public interest in restricting release of Zn, a potentially toxic heavy metal, into the environment. Past experience suggests that regulatory agencies eventually will obtain authority to more closely control Zn use in agriculture. It therefore would be useful to identify Zn products and application practices that reduce the total amount of Zn applied in orchards without compromising fruit tree performance.

I conducted a four-year field trial examining the effectiveness of multiple postbloom applications of 12 Zn spray products: Biomin Zinc (JH Biotech), CM Liquid 9% Zinc (Custom Ag Formulations), Keylate Zinc (Stoller), Nutra-phos 0-24-0 (Pace International), Nutra-phos Zn-K (Pace International), Nutra-spray Zinc (Pace International), Tech-flo Zeta Zinc 22 (Nutrient Technologies), Zinc Metalosate (Albion Laboratories), Zinc X-tra (Custom Ag Formulations), ZincMax (Nutri-Ag), Zinc polyamine (Phyto Chem), and reagent-grade Zn nitrate. The Zn sprays were applied twice per season after bloom to bearing Golden Delicious apple trees at a rate equivalent to 0.5 lb (2000) or 1.0 lb (2001-02) actual Zn per acre per spray. These rates are higher than label rates in some cases and lower than label rates in other cases. No sprays were applied in 2003 to evaluate residual spray effects. Leaf samples were collected in late July/early August of each year, and bud samples in January 2001-03 and December 2003. In 2000-01, the composite leaf sample for each plot was divided into two subsamples. One subsample was oven-dried without washing and ground to a powder in a mill. The second subsample was washed in consecutive detergent and acid baths followed by tap water and deionized water rinses to remove adhering Zn spray residues, oven-dried, and ground. In 2002-03, the unwashed-leaf procedure was not used and the leaf samples were subjected to the detergent plus acid washing procedure only. The buds were oven-dried and ground without washing. All plant tissue samples were analyzed for Zn, nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), boron (B), manganese (Mn), iron (Fe), copper (Cu), aluminum (Al), and sodium (Na) concentrations. The fruit were inspected for spray damage, which appeared as blackening of lenticels.

All of the Zn spray products substantially increased leaf Zn concentration in the unwashed leaves, with the absolute increase varying with product. The detergent plus acid washing procedure substantially reduced leaf Zn concentrations in all of the Zn spray treatments and reduced leaf Fe and Al concentrations in all treatments. The reduction in leaf Zn due to washing indicates removal of Zn spray residues adhering to the leaf surfaces. The relative amounts removed appeared to be related to Zn chemistry or the presence of stickers in the product. The reduction in leaf Fe and Al due to washing is consistent with removal of dust adhering to the leaf surfaces. There were a few inconsistent spray treatment effects on concentrations of the other measured elements in the unwashed and washed leaves, which likely were random statistical events.

The following discussion refers to the Zn concentration in the detergent plus acid-washed leaves, which gives the best estimate of Zn absorbed by the leaf and potentially phytoactive. Reagent-grade zinc nitrate caused the greatest increase in leaf Zn concentration but was the only product that caused fruit marking. Zinc uptake was intermediate in the treatments using organically complexed or chelated forms of Zn and was least in the treatments using inorganic compounds. Among the inorganic Zn compounds, Zn phytoavailability increased in the order: phosphate < oxide < oxysulfate. Winter bud concentrations of the trees receiving Zn sprays were not significantly higher than the water sprayed control in all years, suggesting little accumulation of Zn in the trees from the sprays.

Although there were considerable differences in phytoavailability between the Zn spray products, all of the products were capable of providing sufficient phytoavailable Zn to produce desirable intra-leaf Zn concentrations if applied at high enough rates. The organically complexed and chelated forms of Zn cost more per unit Zn than the inorganic compounds, sometimes substantially more (in at least two cases, up to 235 times more than the cheapest product). The low cost of the inorganic products can beneficially offset their low phytoavailability – using a higher rate of these products can be just as nutritionally effective and often less expensive overall than the more phytoavailable but higher-cost products. The downside of doing so, however, is the undesirable result of releasing more Zn into the environment, which is inconsistent with the objectives of sustainable agriculture. The results also substantiate the WSU recommendation to apply annual maintenance sprays of Zn.

Leaf Nutrient Concentrations in Pear Orchards Managed Using Organic, Soft, and Conventional Farming Practices

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In 2002, members of the Peshastin Creek Growers Association (PCGA) decided to establish an areawide insect pest management program based on the use of organic insect control tactics. They manage about 300 acres of pears. About 50% of the acreage is managed organically, with the remainder using organic insect control management practices but conventional horticultural practices (soft IPM orchards) or both conventional pest and horticultural management practices (conventional orchards). After three growing seasons, reduced fruit yield and sizing have become evident as problems in the organic orchards, particularly in those that have been Certified Organic for greater than ten years.

In Spring 2004, we inspected several of the organic orchards and found that many of the trees in the organic orchards showed strong visual symptoms of nitrogen (N) deficiency, including small pale leaves, poor shoot extension, and a reddish tinge to the bark. We therefore decided to conduct leaf mineral analyses to determine if N deficiency might in fact be present.

We selected 39 of the d'Anjou pear orchards for sampling because this cultivar was the predominant one in the PCGA. Fifty leaves per orchard were sampled randomly on 5-6 August 2004. The leaf samples were washed in phosphorus-free detergent followed by tap water and deionized water rinses, oven-dried, ground, and analyzed for N, phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), zinc (Zn), boron (B), manganese (Mn), iron (Fe), copper (Cu), aluminum (Al), and sodium (Na) concentrations. The effect of orchard management strategy (organic, soft, conventional) on elemental concentrations in leaf tissue was determined using analysis of variance and mean separation by the SNK multiple range test.

Orchard management strategy significantly influenced leaf N concentration (P=0.0003). The organically managed trees had lower leaf N than did the soft and conventionally managed trees. Furthermore, the soft IPM orchards had lower N concentrations than the conventional orchards, despite both soft and conventional using similar horticultural management practices. There are numerous factors which could be responsible for the observed differences in tree N status, including differential N sources, rates and timing, weed control practices, and spray phytotoxicity. The conventional orchards had higher leaf Mg and Mn than the organic and soft orchards. The latter effect is likely due to lower soil pH in the conventional orchards associated with use of urea- or ammonium-containing fertilizers. The organic orchards had higher leaf K than the conventional orchards, likely reflecting the introduction of exogenous K in composts and manures into the orchards. The remaining leaf nutrient concentrations were unaffected by the orchard management strategy, possibly due in part to the routine use of Ca, S, Zn, and B sprays in all of the orchards.

We plan to repeat the sampling and analyses in 2005 to determine the temporal consistency of the leaf elemental data.

Effects of Cover Crops on Mineral Nutrition, Tree Growth and Yield of Organic Apples cv. Gala

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The objective of this work was to evaluate the effects of cover crops on mineral nutrition, tree growth and yield of organic apples cv. Gala/EM planted in 1994 at 4 x 2 m. The study was carried out in the northern Patagonia region of Argentina. The soil was a sandy loam with a pH of 7.6 and an initial organic matter content of 1.5%. In 1999, treatments applied to the inter-row spaces were: 1) permanent cover of alfalfa (*Medicago sativa*) plus fescue (*Festuca arundinacea*) (FA); 2) permanent cover of strawberry clover (*Trifolium fragiferum*) (SC); 3) seeding of common vetch (*Vicia sativa*) (V); and 4) control (natural vegetation of grasses and legumes which is disked in late winter, the traditional management system by growers) (C). Strawberry clover was seeded twice because the plant stand decreased sharply from the first to the third year. On the other hand, the alfalfa/fescue mix remained throughout the study that lasted 6 years but fescue became dominant after year 3 and constituted up to 90% of the stand during the last year. Common vetch was mowed once per year but by mid-November it fell down and decomposed naturally as other grasses (mainly fescue) occupied its niche until March when vetch was sown again. All leguminous seeds were inoculated with specific *Rhizobia* in 1999 but SC and V were not inoculated further. The cover crops were mowed 3 or 4 times during the season and the clippings were left on the ground for natural decomposition.

Irrigation was with microjets and the amount of irrigation water was changed during the season depending on water consumption calculated with Class A Pan coefficients. Organic fertilizer (5-5-5) was added annually from 2001 through 2003 in equal amounts to each treatment in a radius of 0.4 m around the trunk occupied by natural vegetation at a rate of 1.0 kg per tree but due to low N concentration in the leaves in 2004 the application rate was increased by 60% for a total of 2 tons/ha.

Management was conducted within standards related to “organic” certification. There was a frost after fruit set in 2004 that killed the young fruitlets especially in the lower portion of the canopy. Leaf mineral analyses were performed every year starting in the 2000-2001 season. Trunk cross-sectional area (TCSA), tree row volume (TRV) and yield were recorded for the last two seasons when differences among treatments were visible. Data were analyzed as a completely randomized design. For all tree determinations we used 6 rows (56 trees each) per treatment as replicates. Thus, the yield analysis was done evaluating the bins harvested per each row while the TCSA was determined measuring the diameter of each tree in the row. Duncan’s multiple range test was used to separate treatment means found significantly different in the analysis of variance. Statistical significance was tested at 5% level.

Nitrogen concentration decreased steadily in all treatments from 2001 through 2004. Control and alfalfa/fescue treatments reached the lowest values. An increase in the rate of organic fertilizer added augmented the N concentration of leaves in all treatments. Always the treatments with legumes had the best N status. The rest of the nutrients did not show significant differences and all of them remained in normal ranges.

The main response of the trees to the treatments after 6 years was growth as recorded by canopy volume and TCSA. It is noteworthy that soil tillage caused an apparent decrease in tree growth in comparison with the cover crop treatments. Yield was consequently affected as a result of less canopy volume (fruit bearing potential) in the control treatment. It should be borne in mind that there was a frost after fruit set in 2004 that killed the young fruitlets especially in the lower portion of the canopy and yield was 39, 37, 31 and 26 t ha^{-1}, for treatments SC, FA, V and C, respectively. In 2005 yield recorded was 54, 58, 57 and 45 t ha^{-1}, for treatments SC, FA, V and C, respectively.

The reasons for the reduced growth in the Control treatment can be explained by the decrease in soil organic matter and nutrient availability, especially nitrogen. Competition among the cover crop, microorganisms and the tree needs was more aggressive in the Control treatment than in others. Water was always plentiful and the same irrigation regime was imposed in all treatments. Foliar tissue analysis revealed that N became deficient after year 4, especially in FA and C treatments. The increased application rate of N in 2005 balanced tree growth and re-established N concentration to normal levels in all treatments. Tree response was best in treatment C as TCSA increased by 23%.

We conclude that tree growth and yield are affected by soil management. Perennial cover crops perform better than annual common vetch. Disking is not a recommended practice because it decreases the content of soil organic matter and leads to poor tree vigor that corresponds to low fruit bearing potential. However, even with the use of permanent cover crops, the addition of an organic nitrogen fertilizer in proper amounts is mandatory in order to sustain good yields and optimum tree vigor.

The Use of Nematode Faunal Analysis to Ascertain the Effects of Alternative Orchard Floor Management Systems

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Oregon orchardists are interested in how soil biota can be manipulated to optimize nutrient availability. Soil management can alter the soil community in annual and perennial systems (2, 5). Changes in biological parameters are often indicators of change in soil quality (4). Nematode diversity is used as an indicator of soil community structure (1). By identifying the number and groups of nematodes present in soil, we can calculate indices of enrichment (resource availability), structure (stability), and energy channel (slow fungal release of nutrients or rapid bacterial release). Using the indices, we can develop a profile of the soil community and start to understand its ability to cycle nutrients (2).

In 2000, a trial was established in an orchard of 7-year-old 'Fuji' trees on M.26 rootstock at OSU's Lewis Brown Farm in Corvallis, OR, and an orchard of 3-year-old 'Red Delicious' on M.7EMLA rootstock at the Mid-Columbia Valley Agricultural Research and Extension Center (MCAREC) in Hood River, OR, to evaluate how alternative orchard floor management practices affect soil quality, with an emphasis on soil biological characteristics.

At each site cultivation was used as the weed control method. In addition four soil amendment treatments were applied—an unamended control, bark mulch, compost, and a vetch/barley cover crop grown in the alleyway and mown and blown into the tree row. These amendments represented a range of C:N ratios and resource availability. Three replicates of each treatment were applied at each site in a completely randomized design. Each experimental plot consisted of 5 trees with a single tree acting as a buffer between each plot. Weeds were controlled by cultivation.

Nematodes were extracted from soil samples taken at harvest in 2002 and 2003. The total number of nematodes in each sample was counted. Each nematode sample was observed on a microscope slide and the first 100 nematodes observed were classified to genus level. Enrichment index, an indicator of the response of primary decomposers to available resources, and structure index, an indicator of the complexity of the soil community, were calculated (2). These two indices were used to graphically represent the condition of the soil food web in a faunal profile (2). In addition, the channel index (CI), an indicator of the decomposition pathway active in the soil system, was calculated (2).

In neither 2002 nor 2003 were there significant differences among any of the 3 indices at either site. The faunal profile graphs show that at both sites the soil community tended to be more structured (more complex with more trophic levels). All treatments at both sites, except the unamended treatment at Hood River in 2003, fell in quadrat B (Figure 1). This indicates an N enriched system with low disturbance and a maturing soil food web. The decomposition pathway in this system would be balanced between bacterial and fungal. According to Ferris et al. (2) soils from both conventionally and organically managed perennial systems should have faunal profiles that fall in quadrat B or C.

In this study we found no significant differences in the faunal profiles of orchard soils amended with compost, bark mulch, vetch/barley cover crop, and no amendment. This may be due to the stable nature of perennial systems. A longer-term experiment may be necessary to distinguish among the treatment effects.

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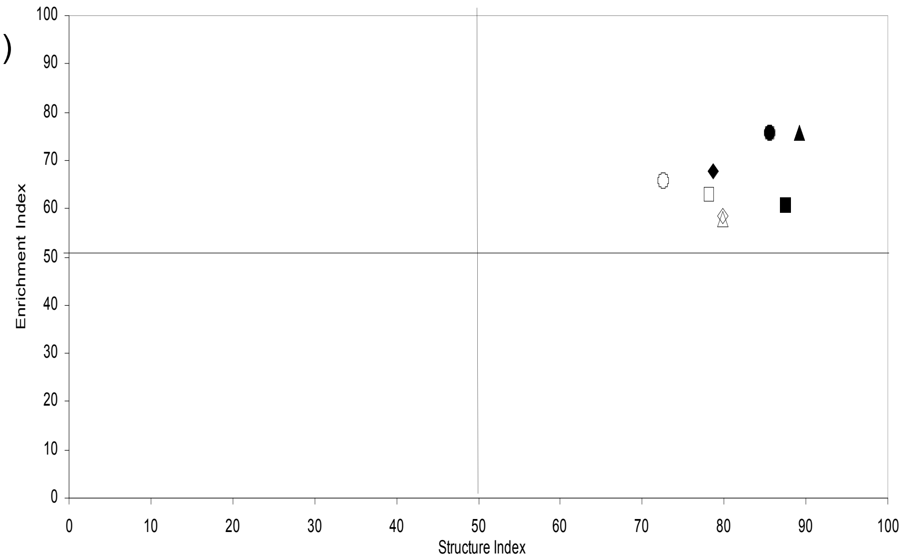
a)



b)

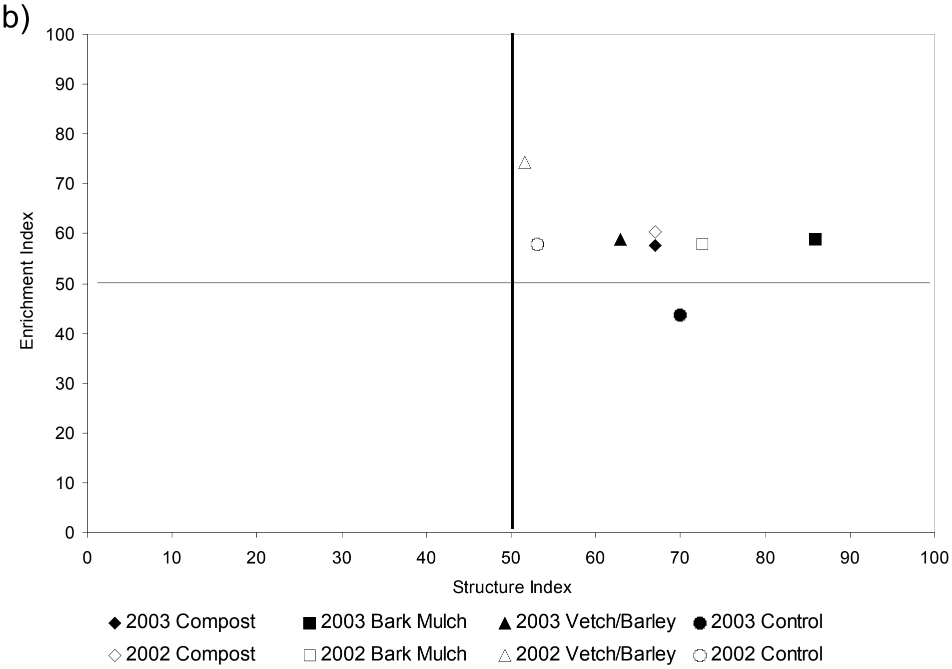


Figure 1. a) Faunal profile for soil amendment plots at Lewis-Brown Farm, Corvallis, OR and b) MCAREC, Hood River, OR.

Organic Mulches Affect Soil Moisture and Temperature during Establishment of Apple Trees

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Introduction

Orchard floor vegetation competes with fruit trees for water and nutrients. Apple trees perform well in the absence of competition from understory vegetation. Many studies have demonstrated that, as the proportion of vegetation-free area increases, the growth and productivity of the tree also increase. Mulch influences soil moisture and temperature fluctuations, two key factors in the establishment and growth of newly planted apple trees. Soil moisture can increase under organic mulches due to improved water infiltration capacity, reduced evaporation, and reduced competition for soil moisture from weeds. Mulch affects the temperature of the soil by acting as a physical barrier that blocks incoming radiation from heating the soil and as an insulator that limits temperature fluctuations. As a result, soil temperatures under mulch are cooler and temperature extremes are smaller when compared to bare soil.

There is a wide range of mulches used in apple orchards including straw, wood chips, black polyethylene plastic, and geotextile fabrics. Several studies evaluating the effectiveness of mulches on apple tree growth have demonstrated a positive effect on soil health, tree growth and fruit yield. A new type of organic mulch has been developed consisting of discarded wool fibers woven into mats of varying thickness. The objective of this study was to characterize the effects of wool mulch on soil moisture, soil temperature and apple tree establishment as compared to herbicide, wood chips, and overall grass orchard floor management systems.

Materials and Methods

The study was conducted at the University of Minnesota's West Central Research and Outreach Center in Morris, MN. The soil at the planting site is a Buse-Barnes loam - calcareous soil formed in glacial till parent material. Bare-root trees of 'Red Mac'/B.9 were planted by hand in May 1998. Trees were tied onto posts and trained to the Slender Spindle system. Trees were spaced 1.2 m apart within rows, 3.7 m between rows and 2.4 m between plots. Each plot consisted of 4 trees in an area of 4.9 m by 1.2 m. Three groundcover treatments were randomly assigned to plots: grass covering the entire plots up to the trunks; wood chips; and wool mulch. Treatments were replicated 8 times in a randomized complete block design.

Mulches were applied immediately after planting. Wood chips were applied in a 10 to 15 cm deep layer and the wool mulch was applied as a 2-ply, 5 cm thick mat cut to fit the plot. Trees were irrigated with 2.5 cm water when soil moisture measured between 30 and 60 centibars. Total precipitation from April to October inclusive was 53.64 cm in 1999 and 46.12 cm in 2000.

Moisture sensors were randomly assigned to four plots representing each groundcover treatment and were placed in each plot at depths of 15, 30, and 45 cm and distances of 30 and 45 cm from one of the middle two trees. Readings were taken daily Monday through Friday from June 14 through September 30 in 1999 and May 17 through September 18 in 2000.

Soil water potential was analyzed over each month within each year at each of the six sensor locations treating the daily measurements within each month as replications. The sensors, located at a depth of 15 cm and distance of 30 cm from the tree trunk and at a depth of 30 cm and distance of 45 cm from the tree trunk, were used to represent the differences seen among treatments and months.

Four temperature sensors were randomly assigned to four plots representing the groundcover treatments. One sensor per plot was inserted 15 cm below the ground within the row of each of the four randomly chosen plots. Soil temperature readings were taken every hour throughout the year. Air temperature was recorded on site at a height of 1.5 m every hour. Data were recorded from January through December in 1999 and 2000. Average daily soil and air temperatures were calculated. Daily temperature fluctuation was calculated by subtracting the minimum temperature from the maximum temperature for each day.

Initial trunk cross-sectional areas were taken on all trees at planting and each fall thereafter at 10 cm above the graft union. The groundcover treatments were tested for differences using analysis of variance procedures (ANOVA) and means were compared using Tukey's HSD at $P \leq 0.05$.

Results and Discussion

Wool mulch and wood chips did not differ significantly in soil moisture levels in all months and sensor locations in 1999. Grass consistently had significantly higher soil water potential than the other three treatments in June through August of 1999 even though the plots were irrigated regularly. However in 2000, grass plots had soil moisture that was not statistically different from one or both of the organic mulches.

When the soil moisture readings from all six sensors were averaged over all months in 1999 and 2000, the wool and wood chip mulches had significantly lower soil water potential over both years. The grass treatment had significantly lower soil moisture than the organic mulches for both years. The ability of mulch to reduce evaporation, increase infiltration, and reduce competition from weeds leads to retained soil moisture. The wool mulch in this study maintained higher soil moisture levels than the grass treatment and was statistically similar to wood chips.

Soil under wood chips had the smallest average daily temperature fluctuation in the months of April, May, July, September, October, and December. Temperature fluctuations under the wool mulch and overall grass plots were higher than those under the wood chips. Many studies have demonstrated organic mulches maintain lower soil temperatures compared to air temperatures in part because of decreased penetration of solar radiation. However, in this study, the wood chip mulch had average daily soil temperatures significantly higher than the air temperature while wool mulch had soil temperatures statistically indistinguishable from the air temperature. The wood chip mulch may have been insulating the soil surface thus limiting heat loss throughout the year. Microbial activity under the mulch may also have helped elevate temperatures during the summer months.

In 1999 and 2000, trees grown with wool and wood chip mulches had significantly greater trunk cross-sectional area than trees in the grass plot. Although wood chips had one of the highest average daily soil temperatures and wool mulch the lowest, growth response was similar. The higher soil temperatures in the wood chip treatment could have been stimulating growth earlier in the season, but in the two years of this study the increase in temperature did not significantly increase tree growth compared to the wool mulch. Increased soil moisture may be affecting tree growth more than increased soil temperature.

Conclusion

Based on this study, organic mulches modified the soil environment and positively affected early apple tree growth compared to overall grass. Future research on the effects, timing and amount of irrigation on apple tree growth could further define the influence of organic mulches in encouraging early tree growth and yield.

Improving Yield and Soil Quality with Mulches and Amendments in Orchards

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Many soils in the major fruit production region of the Pacific Northwest of North America, including southern interior British Columbia, are coarse-textured sandy loams to sands with poor nutrient and water-holding capacities. Such soils are prone to develop management problems including a decline in soil pH, rapid development of various nutrient imbalances and inhibited growth of replanted crops. Increased use of organic matter as mulches or soil amendments has been advocated in orchards in order to improve physical, chemical and biological properties of soils, thus improving their quality.

In the past decade a series of randomized, replicated field trials was established in apple orchards in order to test the effect of various mulches, soil amendments and their combinations on apple tree performance and soil quality.

In a 'Spartan'/M.9 apple orchard planted in April 1994, at a 1.25 m x 3.5 m spacing, different soil management treatments were established and maintained from the first growing season within a 2 m strip centered on the tree row and arranged in a randomized complete block design with 5 replicated 4-tree plots. Treatments included 1) a standard commercial production practice involving maintenance of a weed-free strip, year-round, via multiple annual applications of glyphosate herbicide, and mulch treatments including 2) shredded paper applied uniformly to a weed-free soil surface at 15 kg/plot (establishment) with annual applications of 5 kg/plot to maintain complete cover, 3) alfalfa straw applied initially at 30 kg/plot with annual maintenance applications of 15 kg/plot, and 4) black polypropylene permeable to irrigation water.

A second trial was established in a newly planted Gala/M.9 planting at 1 m x 3 m spacing. Trees were planted in April 1998 and treatments established in July. Three tree plots were established with guards in a randomized complete block design with 6 replicates. Relevant treatments including a spray-on-mulch involving a newsprint residual applied as a 6-8% slurry at 2 kg dry material/m^2 and compared to unmulched check plots where weed control was carried out with annual glyphosate applications.

In a third location involving Gala/M.9 and B.9, four treatments established in 2001 included 1) the standard glyphosate herbicide treatment, 2) spray-on-mulch (as trial 2), 3) also applied over a biosolid/wood waste compost (6 kg/m^2).

Systematic detailed monitoring at all 3 orchards included annual measurement of trunk cross-sectional area, yield and leaf nutrition for all treatment trees. At site 1, after 7 growing seasons, soil samples were analyzed for available nutrients, soil moisture content (also site 3) and water retention capacity.

At site 1, cumulative yield for the first 5 years was least for check trees undergoing standard herbicide treatments. Maximum cumulative yield and tree size were measured for trees grown with a shredded paper mulch. Yield of trees grown with black plastic mulch was also large and these trees were larger than check trees for the first 3 years but thereafter were the same size. Trees mulched with alfalfa had intermediate yield and were larger than check trees for the first 4 years. No changes in leaf nutrient concentration were consistently associated with improved tree performance, possibly because of annual N-fertigation. After 7 years, soil nutrient status was altered when large amounts of nutrients were contained in applied mulches. Thus soil pH and Ca increased beneath the shredded paper mulch and the soil was enriched in P and K beneath the alfalfa mulch. Soil nutrients were generally unaffected beneath the plastic mulch although K had declined, possibly as a result of the lack of organic matter addition to the soil surface in this treatment during the study. The mulches did not alter soil water-holding capacity but were often associated with increases in soil moisture content, a likely consequence of reduced surface evaporation.

At site 2, annual tree vigor and yield were increased in the first 5 years by both spray-on-mulch treatments relative to trees grown conventionally with a herbicide strip. There was no advantage to applying the mulch over shredded paper. Similarly at site 3, newly planted trees had increased tree vigor, as measured by either trunk cross-sectional area or shoot extension growth after first year for the three mulch treatments. Spray-on-mulch treatments reduced weed competition in the first two years and increased soil moisture content as indicated by periodic measurements during the first growing season. Mulches did not consistently affect leaf nutrition.

In summary, surface mulches can improve growth and yield of apple planted in high density systems. Although nutrients contained in organic materials can be released and improve soil nutrient availability, this often is not the causal factor in improved tree performance. Mulches can also buffer against moisture stress, even in irrigated orchards, by moderating declines in soil moisture content. Spray-on-mulches provide benefits similar to organic mulches and frequently increase growth of newly planted apple on dwarfing rootstocks.

Impact of Potential Organic Pesticides and Potential Fruit Crop Regulators on Photosynthesis and Growth of Apple

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Introduction

Alternative crop load regulators (e.g., fruit thinners) and pesticides are needed for both certified organic and conventional fruit production. A post-bloom transient reduction in photosynthesis (Pn) has proven to be an effective technique used for fruit thinning. Conversely, pesticides, which reduce Pn, may be detrimental to plant growth. This three-year study was developed to measure plant response to foliar applications of various acids as potential organic pesticides in a model plant system. In 2004, 21 treatments were screened in five studies. Treatments were applied to vegetatively grown apple trees under controlled environmental conditions to study effects on photosynthesis and plant growth. This model system for screening new compounds will establish a basis for studying additional compounds that may have the potential to be pesticides or fruit thinning agents. The following is a summary of one study.

Objectives

1. To evaluate effects of 2% concentrations of several essential oils on photosynthetic assimilation (A), evapotranspiration (Et), and stomatal conductance (gs) of vegetative model apple trees grown in the greenhouse.
2. To evaluate plant growth response following foliar applications of 2% concentrations of test chemicals.

Materials and Methods

Testing Potential Fruit Thinning Chemicals. Essential oils were tested at a 2% concentration applied as a foliar spray to small, vegetatively growing apple trees grown in a greenhouse. Treatments included cedarwood oil, black pepper oil, cinnamon oil, clove oil, and H_2O-control. Response variables of gas exchange, growth, and leaf morphology were measured for the following 2 weeks as described below.

Plant Material: M.106 apple rootstock liners were planted in 1.9 L pots with a soil medium and grown in the greenhouse with temperatures of 25-30/18-20°C (day/night). At planting, trees were cut back to three nodes above the soil line and new growth was trained to a single shoot with all lateral buds removed as they emerged. Trees were watered as needed. Pests were controlled if detected by scouting. Trees were divided into a number of replications based on the number of treatments (n+1) following previous experience and model power analysis in order to show separation of treatments. The trees were blocked by size at the beginning of treatments and arranged in a random complete block design of treatment applications. When shoots were approximately 10-15 cm in height, treatments were applied. Treatments were applied one time with 1 L spray bottles until leaves were thoroughly wetted. Dependent variables data were analyzed by date of measurement using a Student's *t* test for mean separation ($P>f \leq 0.05$). For all studies planned, a water-sprayed untreated control was used. Treatment data were analyzed as untransformed data but expressed graphically as the percent of the control.

Gas Exchange Measurements: After treatment, gas exchange was measured over a 21-day response period using a CIRAS-1 differential CO_2/H_2O infrared gas analyzer with integral cuvette air supply unit and Parkinson broad-leaf cuvette with an automatic light control (LED unit). Leaf chamber conditions were set for 50% RH, 350 ppm [CO_2]. PAR light saturation for all measurements was set at 1000 µmol/m2/s and temperature of 25-32°C at the leaf surface maintained. The CIRAS-1 was used for the measurements of photosynthetic A, Et, and gs. Two sample leaves, 5-7 nodes from the most recently unfolded leaf, per treated tree were labeled and measured on various dates.

Growth measurements and leaf morphology: A sub-sample set of trees was destructively harvested at the onset of the study for growth characteristics of shoot length (cm), caliper (mm), shoot dry-weight (g), average leaf area (cm^2), average leaf dry weight (g) and specific leaf weight (g/cm^2). Following the 21-day treatment period, all treated trees were destructively sampled for the same measurements. Leaves were removed and divided between treated and those emerged subsequent to treatment. Changes in growth and leaf morphology during the treatment period as affected by treatment were calculated.

Results

Essential oil treatments caused no significant effect on Pn for treatments; however, clove oil was very phytotoxic and defoliated all trees in this study. Cedarwood oil significantly decreased Et and gs one day after treatment. Differences in plant growth were not significantly different among essential treatments excluding clove oil. Various concentrations of clove oil were screened in another study; however, data were inconclusive.

Conclusion

The next focus of this project will screen the best compounds from the 2004 studies. The same methodology will be used to screen individual compounds for the least and most effective concentration for potential use. Additional observations for phytotoxicity or burning of plant tissue will be necessary to establish the impact of various concentration effects on plant tissue. Based upon the findings from these studies, two additional sets of experiments have been proposed and are being developed as follows.

Experiment 2: Evaluation of most effective treatments and effects of treatment concentration. Based upon findings in the first experiment, a subset of chemicals will be selected for additional study. Chemicals selected will be mixed in a range of concentrations (0.5%, 1.0%, 2.0%, 5.0%). The solution characteristics of pH, electrical conductivity, solution osmotic strength, etc. will be measured. For each chemical, a test of concentration effects on gas exchange and growth of vegetative model trees will be conducted following procedures described above. The results of this study will identify specific concentrations for each potential treatment as based upon their effects on gas exchange and growth.

Experiment 3. Field Testing of Potential Fruit Thinning Chemicals by Transient Photosynthetic Inhibition. Based upon the two preliminary model plant studies, treatments will be selected for field testing as fruit thinners (spring 2006). Field trials will be established to test whole tree spray applications. Prior to full bloom, trees for test will be selected and tagged in a completely randomized design with approximately 10 replications. Two sub-sample limbs on each tree will be tagged and the number of flower clusters counted. Approximately 5-10 days after bloom when fruits are 10-15 mm diameter, treatments will be applied. At 45 days after bloom and harvest, fruits on sample limbs will be counted to determine initial and final fruit set, respectively, as fruit/100 flower clusters. At harvest, trees will be sampled and the following data collected; number of fruit/tree, fruit weight, average fruit size, fruit russet rating (0-5 scale). Fruit and trees will be observed for other phytotoxic symptoms which may occur.

Organic Chemical Bloom Thinning of Tree Fruits

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Effective crop load management is critical to successful orchard operations, having profound impact on farm labor costs, fruit size and quality, and annual yields. Chemical thinning is an important element of crop load management, yet organic growers have fewer options than conventional orchardists. The lack of effective OMRI-approved postbloom materials forces organic operations to complete all of their chemical thinning during bloom.

Since 1999, we have conducted nearly 180 replicated field trials of various chemical blossom thinners in commercial Washington apple, pear, cherry, peach, nectarine, and apricot orchards. We have sought to identify and refine programs that improve growers' bottom lines by:

1. Reducing labor costs (primarily due to hand-thinning).
2. Maximizing retention of high quality fruit (improving fruit size, packouts, storability, and eating quality).
3. Promoting annual cropping by improving return bloom.

For apple and pear, roughly half of our trials have been applied by growers using their own spray equipment, while more complex trials were applied by WTFRC staff using a prototype Proptec research sprayer. Each treatment has usually been sprayed twice, typically at 20% and 80% open bloom. Trials were randomized and replicated with untreated controls to accommodate formal statistical analysis of results. Trial sites have included all growing districts, cultivars, rootstocks, and training systems important to the Washington industry. Several apple trials have included segregated harvests and commercial packouts of individual treatments. Stone fruit thinning trials generally have been conducted on smaller scales.

While individual trials have produced variable results, the sheer quantity of trials we have conducted has allowed us to evaluate them collectively and, in doing so, some clear patterns have emerged. Our results demonstrate that oil + lime sulfur thinning programs have achieved each of the three thinning goals most consistently. Our best results have been from a tank mix of Crocker's Fish Oil + lime sulfur, but many other petroleum and vegetable oils have also performed well with lime sulfur. Higher rates of lime sulfur alone have shown good thinning effects but not as often as oil + lime sulfur tank mixes. Third tier performers include NC99 (an OMRI listed magnesium/calcium chloride brine) and the popular conventional blossom thinner ammonium thiosulfate (ATS), both of which have been particularly disappointing in terms of return bloom.

Initial results in pear suggest that lime sulfur alone and oil + lime sulfur programs can achieve some thinning of Bartlett and Bosc but are generally not as effective as ATS. Cherry, peach, nectarine, and apricot results have been highly inconsistent, with oil + lime sulfur programs performing well at times and not at all in others.

Ongoing WTFRC crop load management efforts include cooperation with Don Elfving (WSU, Wenatchee) to evaluate OMRI-listed gibberellins as tools to influence apple flowering behavior. We continue to explore novel timings and chemistries such as vinegar and vegetable oil emulsions for organic chemical thinning in collaboration with scientists around the country including Jim Schupp (Penn State), Curt Rom (Univ. of Arkansas), Steve McArtney (NC State), and Ross Byers (Virginia Tech). Our cooperation with Chang-Lin Xiao (WSU, Wenatchee) has demonstrated that lime sulfur thinning programs can play valuable roles in effective apple powdery mildew programs.

Our results helped lay the foundation for the registration of lime sulfur and lime sulfur + oil programs for chemical thinning in Washington. We have observed dramatically increasing adoption of these programs by both conventional and organic growers throughout the state who generally report good results consistent with what we have observed in our structured trials. While organic growers may not be able to rely on postbloom thinners such as carbaryl, NAA, NAD, ethephon, or benzyladenine, they have several excellent options available as blossom thinners.