PROGRAM AND ABSTRACT BOOK

This book contains the general symposium program, followed by the abstracts and a list of attendees. Each session includes the page numbers where the abstracts for that session can be found. The oral abstracts are listed first in the order of their planned presentation during a session, then followed by abstracts under that topic that will be presented as posters, where they will be grouped by topic. Several abstracts were accepted but the author was unable to attend; these abstracts are included, and indicated as such, in order to increase awareness of the scope of current organic fruit research.

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Organizers and Financial Support

The 2nd International Organic Fruit Research Symposium is being held under the auspices of the International Society of Horticultural Science (ISHS), Commission on Sustainability through Integrated and Organic Horticulture. It builds upon previous meetings in Vignola, Italy (2008) and Nova Scotia, Canada (2006) as well as several North American Organic Tree Fruit Research conferences. Washington State University has provided critical support for the planning and execution of the event. The Symposium planning and scientific committee includes the following members:

- David Granatstein, Center for Sustaining Agriculture and Natural Resources, Washington State University, Wenatchee, WA USA; Co-convener
- Preston Andrews, Dept. of Horticulture and Landscape Architecture, Washington State University, Pullman, WA USA; Co-convener
- Harold Ostenson, H. Ostenson Consulting, and former Director, Stemilt Growers Organic Program, Wenatchee, WA USA; Co-convener
- Deirdre Birmingham, Board President, Organic Farming Research Foundation (OFRF), and The Cider Farm, Mineral Point, WI USA
- Jay Brunner, Washington State University, Wenatchee, WA USA
- Steve Ela, Ela Family Farms, Hotchkiss, CO USA
- Chuck Ingels, University of California Cooperative Extension, Sacramento, CA USA
- Wojciech Janisiewicz, USDA Agricultural Research Service, Kearneysville, WV USA
- Karen Lewis, Washington State University, Ephrata, WA, USA
- Jim McFerson, Washington Tree Fruit Research Commission, Wenatchee, WA USA
- Greg Peck, Virginia Polytechnic Institute and State University, Winchester, VA USA
- Bob Prange, ISHS representative and formerly Agriculture Canada, Nova Scotia, Canada
- Curt Rom, University of Arkansas, Fayetteville, AR USA
- Franco Weibel, Research Institute of Organic Agriculture (FiBL), Frick, Switzerland
- Chang-Lin Xiao, USDA Agricultural Research Service, Parlier, CA USA

ISHS symposia are self-supporting. This event was made possible by financial and other contributions from the following organizations and industry sponsors:

- USDA-NIFA Organic Research Education Initiative conference grant
- USDA-ARS Office of Technology Transfer grant
- Washington State University Center for Sustaining Agriculture and Natural Resources, WSARE PDP support
- Washington Tree Fruit Research Commission travel grant
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Industry sponsors:

- Columbia Valley Fruit LLC, Yakima, WA
- Stemilt Growers LLC, Wenatchee, WA
- Earthbound Farm, San Juan Bautista, CA
- G.S. Long Co. Inc., Yakima, WA
- Crunch Pak LLC, Cashmere, WA
- CF Fresh Inc., Sedro-Woolley, WA
- Zirkle Fruit Co., Selah, WA
- Wilson Orchard and Vineyard Supply, Yakima and Wenatchee, WA
- Dow AgroSciences, Indianapolis, IN

The committee would like to thank the many people who helped make this event possible. These include conference planners (Kelley Kennedy, Carly Morse), on-site assistants (Cindy Kahn, Amanda Mattingly, Luke Gustafson, Christie Lumpkin, Johanna Nodop, Nataliya Shcherbatyuk, Mary DiMatteo), and Cindy Armstrong for fiscal and administrative support.

Symposium Program At A Glance		
Time	**Session**	**Room**
	Monday, June 18	
1500-1900	**Registration opens**	Lake Wenatchee Room (by hotel lobby)
1500-1900	**Poster set-up**	Ballroom and Icicle Ridge Room
1830-2030	**Welcome Reception**	Ballroom
	Tuesday, June 19	
800-1000	**Plenary 1. The Organic Fruit System (p. 4-5)**	Ballroom
1000-1015	**Break**	
1015-1215	**Plenary 1 (cont'd). The Organic fruit system; OREI projects**	Ballroom
1215-1315	**Lunch**	The Garden
1315	**Concurrent Session 1A. Insect Biocontrol (p. 6-9)**	Ballroom
	Concurrent Session 1B. Horticulture 1 (p. 12-19)	Icicle Ridge Room
1445	**Break**	
1515	**Concurrent Session 2A. Plant Pathology (p. 9-12)**	Ballroom
	Concurrent Session 2B. Horticulture 2 (p. 14-15)	Icicle Ridge Room
1700-1915	**Poster Session – Refreshments**	Ballroom (and Icicle Ridge Room)
1915	**Adjourn –Dinner on your own**	
	Wednesday, June 20—Field Tour	
715	**Start loading buses, depart at 730am**	Main entrance
	Thursday, June 21	
800	**Plenary 2. Soil Management (p. 19)**	Ballroom
850	**Concurrent Session 3A. Soils and Crop Nutrition (p. 20-23)**	Ballroom
	Concurrent Session 3B. Organic Fruit Systems (p. 23-25)	Icicle Ridge Room
1030	**Break**	
1045	**Concurrent Session 4A. Research Funding Panel (p.25)**	Ballroom
	Concurrent Session 4B. Economics (p. 26)	Icicle Ridge Room
1200	**Lunch, ISHS business meeting**	The Garden
1330	**Plenary 3. Organic Fruit: Impacts and Progress (p. 27-28)**	Ballroom
1500	**Break**	
1515	**Plenary 4. Closing – Session Summaries, Next Steps**	Ballroom
1700	**Adjourn**	

Note: page numbers after session topics refer to the location of the abstracts for those oral presentations and posters on that topic.

Plenary 1. The Organic fruit system; OREI projects

The U.S. Market for Organic Fruits

D. Harris
Harris Consulting Solutions, Boulder, CO USA

This presentation will explore the opportunities and trends associated with organic fruit sales in the United States and examine the ways that the momentum of sales increases (up 11.7% per year) can be maintained and even increased. We will look at the sales trends in terms of how to increase the penetration of organic interest beyond 30% of the population. This includes understanding the important demographics, education and income, and how they affect the purchase intent of consumers. Price premiums for organic fruit will be explored - how much can be charged for an organic product versus conventional? Is 40% too much, is 20% too little? How can we maintain or increase the 93% of total organic produce sales represented by fresh organic fruits and vegetables. What will need to be done to increase the share of fruit in organic produce sales from its present 30% share? In the big picture, we will consider the potential to increase sales of organics from its present 4.8% to 6% and even 10% of total food sales. We will also look at how additional categories can grow their percentage of the organic produce sales similar to apples and packaged salad. Overall we will discuss how to push the sales of organic fruits and vegetables over the $11.8 billion sold in 2011. Ultimately we will look at how we can increase the numbers of organic fruit varieties being displayed in the produce department from the present 20 to 25, to a larger number closer to 50.

Organic Fruit Growing and Markets in Europe in the early 2010s: Solutions, Challenges and Perspectives

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Europe is both a leading world market for and world producer of organic food. Growth of organically managed land continued during the financial recession. But EU government support for organic farms, which has been important in its expansion, is set to end in 2013. However, many countries have specific plans for priority organic research and investment. Europe is a major producer of organic fruit crops, including 192,700 ha of grapes, 187,000 ha of nuts, 94,800 ha of temperate fruit, 26,096 ha of berries and 31,800 ha of citrus. Western Europe has added 4,000 ha of organic apples (*Malus* x *domestica*) in the past two years due to growth of the organic fruit market, a decline in conventional fruit prices, important progress for improved organic production methods and input products. There have been signs of market saturation in years of high organic apple yields, and thus organic fruit growers and retailers are working to gain new customers, especially LOHAS (lifestyle of health and sustainability) consumers. Tools to help organic fruit growers better evaluate farm economics (e.g. 'Arbokost') are available and needed as increased prices are often nearly matched by increased production costs. New disease control products and models are helping address key fruit diseases such as apple scab (*Venturia inequalis*) and sooty blotch (*Gloedes pomigena* and *Schizotorium pomi*), yet barriers for other fruits remain. As conventional fruit production embodies more sustainability and dramatically reduces pesticide residues, the perceived added value of organic fruit by consumers could diminish. Research at FiBL and elsewhere is attempting to redesign organic fruit systems to be more self-regulating by choosing fruit genetics that minimize input needs and increasing biodiversity in the farm ecosystem, thus continuing to distinguish organic production from other methods.

* Denotes the presenting author

Fungal Disease Management in Organic Fruit Orchards: epidemiology, forecasting and disease control strategies

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Interest in organic fruit production has expanded in recent years, where management practices differ from those in conventional production. Synthetic products are generally not allowed in organic fruit production; for example, in plant protection and nutrient supply, only natural products are permitted according to IFOAM standards. As a result, disease control is less effective than in conventional or integrated production and thus disease epidemics are likely to be more serious in such a system. This lecture provides current management options against key fungal diseases of fruit crops. Then development of fungal disease management in pome and stone fruit species are demonstrated by focusing mainly on key fungal diseases such as scab and brown rot. This includes epidemic features of diseases in organic orchards, a risk of fungal epidemics initiated by sexual and asexual forms of fungi in organic orchards, possible control strategies against inoculum sources in organic production systems, efficacy and phytotoxicity of approved fungicidal products and appropriateness of various sanitation practices in organic fruit production as well as the role of resistant *vs.* susceptible cultivars in disease epidemiology and management of organic orchards. Based on above examples, a theoretical and practical decision-making approach and future trends in fungal disease management are provided for organic orchards based on mechanical, agro-technical, biological and chemical control options.

Biological Pest Control in Organic Tree Crops in the Western U.S.: An Overview

N. Mills
Department of Environmental Science and Policy Management, University of California, Berkeley, CA USA

Biological control is an economically valuable and naturally occurring pest control service provided by natural enemies that can play a pivotal role in the management of arthropod pests. Natural enemies can be effectively manipulated to enhance biological control through classical introduction (invasive pests only), augmentation and conservation. Classical introductions of exotic natural enemies in western USA orchards have provided long-term successes in the biological control of some groups of invasive pests in tree crops, such as the cottony cushion scale in citrus and the walnut aphid. Periodic release of mass-reared natural enemies to locally augment their activity in western orchards has been successful for California red scale, but in other cases has met with more variable success that is dependent upon the technical effectiveness and commercial viability of the natural enemy species. Conservation of natural enemy activity through selective usage of organic pesticides has also provided opportunities for sustainable pest management in western orchards, such as for spider mites and western tentiform leafminer, with significant economic benefits. Western orchards provide some excellent examples that illustrate the importance and value of biological pest control in organic production that will be presented and discussed in relation to future opportunities for biological control of direct versus indirect pests.

The Potential Impacts of Genetics, Genomics and Breeding on Organic Fruit Production

K. Evans
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New technologies available to plant breeders are increasing the possibility of successful targeted selection for a range of characteristics, resulting in new varieties some of which may have more potential for

organic production over current varieties. DNA-assisted selection in traditional breeding programs can increase the efficiency of selection for robust disease or pest resistances whilst also enabling the breeder to select for good fruit quality. Projects such as the EU-funded DARE and HiDRAS resulted in advances in tools enabling the breeder to pre-select for resistance to apple scab (*Venturia inaequalis*) and powdery mildew (*Podosphaera leucotricha*); other on-going projects (e.g. Norelli et al.) are developing similar tools linked to resistance to fire blight (*Erwinia amylovora*). Whilst the RosBREED project is focused on fruit quality traits, the principal aim of the project is to enable breeders to implement the DNA-assisted technology thus having a much greater impact on the production of new Rosaceae products in the USA. This paper will describe the application of new technologies in traditional breeding programs as well as discuss the further possibilities for advances in molecular biology and genetic modification to offer new breeding systems that are acceptable for organic agriculture for the development of new improved varieties.

OREI: Impacts of the Organic Research Network Project on the Central Coast of California

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The California organic agriculture industry has grown in size and consumer acceptance despite a very limited scientific research base. The Organic Research Network Project, funded by USDA-Integrated Organic Program in 2004 (Stephen Gliessman, P.I.) was designed to 1) strengthen an existing organic research and extension network to support organic vegetable and strawberry producers in the region; and 2) develop integrated fertility and pest management strategies in order to minimize negative impacts of agriculture on surrounding natural ecosystems, and improve the economic viability of organic farming. To evaluate the impact of the project, we conducted pre- and post-project assessments. At the end of the project 15 of the 18 participants said it had met or exceeded their expectations and the remaining 3 said that most of their expectations were met. Participants were motivated by a desire to build community, increase opportunities to collaborate, improve linkages between farmers and researchers, and improve access to and exchange of information. Participating growers appreciated the many opportunities for interaction with researchers, felt the project provided useful information, and reported that it had either reinforced or changed practices used on their farms. Extension agents commented on the successful collaborations, improved knowledge of organic production and the impact it had on growers in the area; one commented that "There has been a quantum leap in the knowledge obtained about strawberry fertility…the study has become a standard and is routinely referred to by growers, researchers and industry professionals." One important outcome is the "Organic Strawberry Manual" currently being published. The Organic Research Network is further expanding with new funding from the USDA-OREI program in 2011 (Carol Shennan, P.I.).

The OrganicA Project - Evaluating New Opportunities for Organic Apple Production with Five Apple Cultivars in the New England Region of the USA

L.P. Berkett*[1], R.E. Moran[2], M.E. Garcia[3], H.M. Darby[1], R.L. Parsons[1], T.L. Bradshaw[1], S.L. Kingsley-Richards[1], and M.C. Griffith[1]
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Apples (*Malus* x *domestica*) are an important component of agricultural diversity in the New England region, USA. Within the region, there are approximately 5,746 ha in production, with an average utilized production value for the past five years of $64.5 million. Sustainable and profitable organic apple production has been a long-existing goal of organic farming in the region. However, only a small number of orchards are organically certified. Many more apple growers are interested in producing organic apples; the small number reflects, in part, the arthropod and horticultural challenges of organic apple production and the disease challenges associated with the traditional cultivar grown in the region (i.e., 'McIntosh'). Over the past few years, shifts in consumer preference for 'newer' cultivars has led to the planting of different apple cultivars in New England which have different disease susceptibilities, and research has identified potential alternatives for arthropod and horticultural obstacles in organic apple production. Growers want to know what the potential is for sustainable and profitable organic apple production with the newer cultivars being planted. In 2006, after extensive input from growers, the OrganicA Project was developed and initiated through a major grant from the USDA Integrated Organic Program and was continued in 2009, through a major grant from the USDA NIFA Organic Research and Extension Initiative (OREI). The OrganicA Project is examining the opportunities and challenges of organic apple production within the two major orchard systems growers are using to change to new cultivars and with five of the top apple cultivars that growers identified as important to the future of the industry. The long-term goal of this project is to enhance adoption of organic apple production in New England through holistic research that advances the scientific knowledge base and provides practical information to stakeholders.

Holistic Integration of Organic Strategies and High Tunnels for Midwest/Great Lakes Fruit Production

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Growers who want to produce organic fruits in non-arid cool climate areas like the Midwest/Great Lakes need expanded strategies for soil, plant, pest (insect, disease, weed) and environmental management to enhance crop diversity, productivity, market opportunities, and profitability. Research begun in 2005 on multi-bay high tunnel production of brambles (*Rubus* spp.) and sweet cherries (*Prunus avium*) revealed some distinct advantages that might better facilitate organic production. The MSU Organic High Tunnel Fruit project was initiated with funding from the Ceres Organic Trust in 2009 and established fully with funding from the USDA-NIFA Organic Research and Extension Initiative in 2010 (Award 2010-51300-21395). The project goal is to develop and disseminate knowledge for integrating organic production systems with environment-modifying techniques, such as high tunnels, to discover holistic and synergistic strategies for crop protection, soil building, season extension, and the expansion of organic production potential for brambles, sweet cherries, and apple (*Malus* x *domestica*) nursery trees. Practices to be studied include composts, cover crops, biodiversification, ecological weed management, and crop canopy management. Soil building and health maintenance in perennial fruit systems under high tunnels is a particularly unique and little-studied need that is critical for sustainable organic fruit production in the Midwest region. Stakeholder partners include a comparative (non-high tunnel) organic grower for each fruit crop, with the high tunnel apple nursery tree production being conducted both at MSU and with the organic apple stakeholder. Project outreach will include: a) educational programs and demonstration plot walks in association with the MSU Student Organic Farm, b) on-farm trials and workshops with stakeholders, c) on-line delivery of organic farming principles and practices, and d) development of extension publications and professional journal articles. Project outcomes will help organic farmers extend their seasons, improve their ecosystem services, and diversify their production and market potentials.

Concurrent Session 1A. Insect Biocontrol

Monitoring and Modeling Natural Enemies to Enhance Biological Control in Western US Tree Crops

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Integrated Pest Management (IPM) programs in western USA tree crops (apple, pear, and walnut; *Malus* x *domestica*, *Pyrus* sp., and *Juglans* sp., repectively) are changing rapidly in response to the loss of organo-phosphate (OP) insecticides, the detrimental effects of OP replacements, and the use of mating disruption for key lepidopterous pests. A key feature of the new IPM programs is a greater reliance on conservation biological control of the most important natural enemies, which moves them closer to organic management tactics. However, conservation biological control requires that we understand natural enemy phenology and abundance throughout the season. To adequately model natural enemy phenology, we need sampling methods that provide a reasonable estimate of natural enemy density over time. Current sampling technologies are inefficient and time consuming, limiting their possible use. We present data on the development of Herbivore-Induced Plant Volatiles (HIPVs) sampling tools including information on lure longevity, attractiveness of mixtures of HIPVs, potential for compliance with organic standards, and trap design. We also provide information developed using these lures over a two year period that show the density of lacewings (*Chrysopa* and *Chrysoperla* sp.) and syrphid flies (*Eupeodes* sp.) is >2 fold higher in organic orchards than in conventional ones. Field data on natural enemy abundance generated by these lures can also be used along with temperature and laboratory development data in the development of natural enemy models. Our models are demographic degree-day models that provide not just phenology, but also allow the modeling of pesticide impact on pest and natural enemies throughout the season. The impact of these monitoring and models on IPM program design is discussed.

Habitat Modifications and Species-Specific Pest Control Products Can Reduce Pest Control Costs

T.R. Unruh
USDA-ARS Fruit and Vegetable Insect Research Unit, Wapato, WA USA

Creation of wild rose (*Rosa woodsii*) habitats near orchards can enhance biological control of pest leafrollers in orchards by providing an overwintering host for the beneficial parasitic wasp, *Colpoclypeus florus*. Data spanning seven years demonstrate the value of this orchard habitat modification. Maintenance of an understory that is diverse can increase predatory insects and spiders. A large complex of orchard dwelling predators, including ground beetles, spiders, and earwigs can contribute to biological control of several pests including the codling moth, *Cydia pomonella*. Data from predator gut content analyses show how a rich predatory fauna in the understory can help reduce the explosive reproductive capacity of codling moth. A previous study in the state that showed that creation of predator refuge structures in apple trees promoted control of aphid pests. All these modifications are sustainable and inexpensive for organic growers to implement. A key benefit of mating disruption and granulovirus for codling moth control includes preservation of beneficial insects. In contrast, some beneficial insects are negatively impacted by a spinosad-containing biopesticide commonly used by organic tree fruit producers.

Three for One: An Organic Adjuvant that May Improve Management of Fruit Flies, Diseases, and Birds in Cherry and Small Fruits

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A new bait (sugar plus yeast) is being researched for management of spotted wing drosophila (SWD) (*Drosophila suzukii*) that may also improve control of foliar and fruit diseases, and the avian pests starling (*Sturnus vulgaris*) and robin (*Turdus migratorius*) in cherry (*Prunus avium*), blueberry (*Vaccinum* sp.), and caneberries (*Rubus* sp.). Organic growers have limited control options for SWD as neither of the protein baits that are effective for tephritid fruit flies (GF-120® or Nu-Lure®) appears to provide sufficient control. Yet, the stimulatory effects of yeasts and sugars on fly feeding are well known and recent studies with the Western Cherry Fruit Fly (*Rhagoletis indifferens*) show that their addition can significantly improve the performance of insecticides. At the same time, several cherry and apple (*Malus* x *domestica*) growers in Washington State, USA have adopted the use of cane sugar sprays on orchard trees to repel bird pests. The target species lack the sucrase enzyme and thus, when they feed on sucrose, they apparently become sick and through associative learning avoid the crops treated with sucrose. An initial trial in 2011 appeared to confirm this response. Additionally, several species of antagonistic yeasts can provide biological control of severe post-harvest disease organisms affecting cherry, such as *Botrytis*, *Alternaria*, *Aspergilus*, *Rhizopus*, and pre-harvest pathogens such as brown rot (*Monilinia fructicola*) and cherry powdery mildew (*Podosphaera clandestina*). To date, we have used several antagonistic yeasts to improve the insecticidal activity of several materials including the organic spinosyn formulation, Entrust™. Our current results and ongoing research program will be discussed.

Effect of a Commercial Extract of the Brown Seaweed *Ascophyllum nodosum* on Mites in Tree Fruit

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Mites are a relatively ubiquitous pest of agricultural crops. Damage can include defoliation leading to sunburned fruit, and a yield reduction in current and subsequent years. Seaweed extracts are often used for increasing fruit size as well as yield and quality; however, reduced mite populations have also been reported. A reduction in mite levels in plants that have been treated with seaweed extracts can be found in older published literature; however there is less recent published work. The objective of this trial was to evaluate the effect of the seaweed (*Ascophyllum nodosum*) extract Stimplex™ [Acadian Seaplants Limited (ASL), Dartmouth, Nova Scotia] on phytophagous mites of apples (*Malus* x *domestica*) and pears (*Pyrus communis*) in the Pacific Northwest, USA. Studies were conducted at two sites near Moxee, Washington, in 2011. Applications of seaweed extract were made according to a standard program recommended by ASL. Samples of 50 leaves were collected from each plot and mites were identified and counted, four times throughout the growing season. At one site, there was a mite outbreak that was above the established economic injury level. Populations of European red mites (*Panonychus ulmi*), brown mites (*Bryobia rubrioculus*), and two spotted spider mites (*Tetranychus urticae*) were lower in the seaweed extract treated plots, as compared to the controls. Results from these two studies suggest that a seasonal program of Stimplex™ can help to suppress several species of phytophagous mites attacking pome fruits. Mite suppression would appear to be an additional benefit to improved yield and quality for growers using this natural product.

Green Peach Aphid (*Myzus persicae*) Control in Organic Plum Orchards

L. Cichon, S. Garrido*, J. Lago, and M. Fernanda Menni
INTA, Alto Valle (Río Negro) Experimental Station, Gral. Roca, Argentina

The green peach aphid (*Myzus persicae* (Sulzer)) is a limiting pest in organic plum (*Prunus doméstica* L.) production in different regions of the world, resulting in defoliation and premature fruit fall. The efficacy of two botanical insecticides, VGP (*Melia azedarach,* 80%, *Allium sativum,* 8% and *Casuarina cunninghamiana,* 12%) 500 cc/hl^{-1} and NeemAzal (*Azadirachtina* 1.2 %) 350 cc/hl^{-1}; was assessed and compared to untreated control group. Petal-fall applications were carried out on Sep. 25, 2010. VGP treatment was re-applied 20 days later due to the pest population density increase in that treatment. The experimental design was completely randomized, with 4 replications per treatment, 3 trees per replication and 5 shoots per tree (60 shoots per treatment). Statistical analysis used a generalized linear model. The model was characterized through Poisson distribution and the link function was logarithmic. In those cases where overdispersion was detected, a scale parameter was used for the correction. Weekly sampling took place until Nov. 12. The number of green aphids decreased in all treatments after Nov.12 due to the predatory action of lady beetles (*Coleoptera: Coccinellidae*), especially in the control treatment. NeemAzal was the most effective treatment, keeping populations under 15 aphids per shoot during the period of highest risk of *M. persicae* attack (45 days after petal fall). Moreover, the size and number of fruits and the foliage remained unaffected.

Organic Management of Fruit Fly in Jujube Ecosystem

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A study of organic management of fruit fly species in the jujube (*Ziziphus mauritiana)* ecosystem was carried out in the field at the Agriculture Research Institute, Tandojam, from November 2008 to March 2009. Infested jujube fruits were collected and brought into the laboratory. The efficacy of bio-pesticides on controlling fruit flies from harvested fruit heaps was 4, 10, and 27% infestation for neem powder, tobacco extract, and the untreated control, respectively. Based on the fruit infestation level recorded from fallen fruits, maximum control was achieved with Neem powder (15% damage), followed by tobacco extract (25%) and control (39%). The fruit were infested by three species of fruit fly. The highest infestation rate was by *Bactrocenra zonata,* (91% of fruits infested), followed by *Carpomia vesuvian* (6%) and *Bactrocenra dorsalis* (3%). Experimental results indicate that neem powder and tobacco extract can be recommended for application for controlling fruit fly on jujube orchards.

Insect Biocontrol - Poster Session

Assessment of Kelp Extract Biostimulants on Arthropod Incidence and Damage in a Certified Organic Apple Orchard

T.L. Bradshaw[1*], L.P. Berkett[1], H.M. Darby[1], R.E. Moran[2], R.L. Parsons[1], M.E. Garcia[3], S.L. Kingsley-Richards[1], and M.C. Griffith[1]
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Organic farmers commonly use natural biostimulants in their fertility program to supplement mineral nutrition. These materials are a poorly-defined group of products that are not plant fertilizers, but which, when used in small quantities, may improve plant growth or function. In 2009 and 2010, two biostimulant materials extracted from kelp (*Ascophyllum nodosum)*, Stimplex® and Seacrop16™, were applied as horticultural treatments and tested against a non-treated control in a certified organic apple (*Malus* x *domestica*) orchard in South Burlington, VT. The objective of this study was to assess non-target effects from application of kelp extract biostimulants on incidence of arthropods and their damage on foliage and fruit in the study orchard. Kelp extracts were applied at labeled rates seven times during each growing season to each of five replicates of the cultivars 'Ginger Gold', 'Honeycrisp', 'Liberty', 'Macoun', and 'Zestar!'. Treatments were applied in a completely randomized design and the same treatment was applied to the same trees in both study years. Data were analyzed with a two-way ANOVA with separate cultivar and kelp extract treatments. Results indicated that generally there was no effect of kelp extracts on arthropod incidence or damage on foliage or fruit. Reduced incidence of apple maggot damage on fruit was observed on kelp extract treatments in 2009 under low pest population conditions.

The Effect of Compost on Extending Entomopathogenic Nematode Lifespan and Lethality Against Plum Curculio in Apple Orchards

R.D. Selby, P.N. Nelson, and M.E. Whalon (presented by G. Bird)
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When entering the soil to pupate, plum curculio (PC) (*Conotrachelus nenuphar*) are vulnerable to predation by entomopathogenic nematodes (EPNs) in their infective juvenile form, but these are typically only active in soil for a few days. In a Michigan, USA, orchard in summer 2011, two EPN *Steinernema* species added to bags of buried soil were mixed with three different varieties of compost and one clay-soil control to try to improve EPN lifespan and efficacy through the creation of a more suitable microclimate on the orchard floor. Plum curculio larvae were added to the bags at different time intervals. Overall, the PC kill rate with EPNs in the bags was higher than the 50-70% reported over a 2 week period, using in-ground pots in Michigan orchards in 2008. Plots treated with *Steinernema riobrave* had a higher average PC kill rate than those treated with *S. carpocapsae*. A straw/hay/vegetable compost mix resulted in a higher average PC kill rate when using *S. carpocapsae*. We also measured a significant spatial effect, with a higher PC kill rate in orchard edge rows influenced by greater shade and softer soil from adjacent poplar (*Populus* sp.) trees. Results from winter laboratory tests will also be discussed.

Alternative Monitoring and Management Tactics for Rednecked Cane Borer in Blackberries

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Blackberry (*Rubus fruticosus*) production in the eastern United States faces an insect pest that threatens nearly all the 7,100 tons of fruit produced annually from 2,500 acres of blackberries in this region. The rednecked cane borer (*Agrilus ruficollis)* has been shown to affect nearly 72% of blackberry canes and predisposes galled canes to winter injury. Control of this pest has relied upon hand removal of galled canes or applications of imidacloprid, an insecticide not allowed in organic production. Experiments were conducted to develop alternative monitoring and control tactics against the rednecked cane borer. For monitoring, we compared attractiveness of traps mimicking cane and leaf colors of primocanes and floricanes, or painted yellow, purple, and unpainted (control). Several insecticides and biopesticides were tested for efficacy to determine if other chemistries will control this pest besides imidacloprid. Results from the trapping experiment showed a significantly higher adult capture on traps mimicking canes painted primocane and floricane green than all colors of leaf traps or yellow cane traps or controls ($P < 0.05$). Results from the efficacy study demonstrated that imidacloprid and organic JMS Stylet oil had significantly less galls per plot compared to the control plots. Further research is being conducted to determine the appropriate color and shape of traps and if these traps could be used for mass trapping to lower local rednecked cane borer populations and minimize galling. With organic JMS Stylet oil showing some promise as an alternative to imidacloprid, larger scale tests should be conducted to see if effectiveness is still achieved.

Lures, Mating Disruption and Mass Trapping of Grape Root Borer

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Isonet-Z dispenser that emits the sex pheromone blend of the leopard moth, *(Zeuzera pyrina* (L.) (Lepidoptera: Cossidae), was evaluated as a lure and for mating disruption for grape root borer (GRB) (Lepidoptera: Sesiidae), *Vitacea polistiformis* (Harris), whereas traps baited with the GRB sex pheromone lure were used to attract and kill GRB. The GRB is a key root pest of winegrapes and muscadine vines (*Vitis* spp.). The Isonet-Z dispenser pheromone blend was 95% (E,Z)-2,13-octadecadien-1-ol-acetate (hereafter called E,Z-2,13-ODDA): 5% (E,Z)-3,13-octadecadien-1-ol-acetate (hereafter called E,Z-3,13-ODDA). The GRB sex pheromone was a 99:1 blend of (E,Z)-2,13-ODDA and Z,Z-3,13-ODDA. To date, growers have used a variety of other management practices to reduce adult GRB emergence from soil or to prevent larvae entering soil including: soil mounding or landscape cloth under vines; or a soil barrier of the insecticide chlorpyrifos. This study compared: attractiveness to GRB of Isonet-Z dispensers to GRB sex pheromone lures; three densities of Isonet-Z dispensers per acre to disrupt mating of GRB; and if a GRB sex pheromone baited green bucket trap at density of one trap per acre would attract and kill GRB. Traps baited with GRB pheromone using a rubber septa dispenser captured significantly more GRB males than did traps baited with a leopard moth pheromone rope containing the Isonet-Z dispenser. In Florida and Missouri, zero GRB moths were caught in GRB pheromone baited traps set in muscadine or winegrape plantings exposed to mating disruption treatments with 150, 200 or 300 Isonet-Z dispensers per acre. In Missouri, more GRB moths were captured in winegrape plots subjected to mass trapping with density of one GRB pheromone baited trap per acre than untreated or plots with mating disruption. The economics of each GRB pest management tactic is discussed.

Seasonal Occurrence of Apple Heliodinid Moth and its Control by Environmentally-Friendly Measures in an Organic Kiwifruit Orchard

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The apple heliodinid moth (AHM) (*Stathmopoda auriferella*) is one of the most serious pests in organic kiwifruit (*Actinidia deliciosa* cv. Hayward) orchards in Korea. Several environmentally-friendly cultural practices were tested for the control of AHM in commercial organic kiwifruit orchards in Haenam at the southwest end of Korean peninsula. There were two seasonal peaks of AHM observed. The first peak occurred between early and mid-June and the second was between early and mid-August. Therefore, most control measures were focused on the period from May to September. The installation of AHM-attracting black lights in a kiwifruit orchard led to 15% greater AHM mortality and 34% less fruit damage than with normal whitish-orange colored lights. Several natural extracts were also tested for AHM control. Among them, three plant extracts from *Sophora flavescens*, *Cinnamomum zeylanicum* and *Azadirachta indica* and a B.t. (*Bacillus thuringiensis*) liquid provided >80% control in field trials. Early fruit bagging right after fruit set has also provided a high level of control for AHM. Also, there was significantly different AHM damage between green 'Hayward' (*Actinidia deliciosa*) and gold 'Haegeum' (*Actinidia chinensis*) kiwifruit. Gold kiwifruit had 3.6% fruit damage versus 34.3% damage in green kiwifruit.

Control of the Greater Peach Tree Borer in Small-scale Organic Orchards

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The Greater Peach Tree Borer (*Synanthedon exitiosa*) (Lepidoptera: Sesiidae) lays its eggs on the lower trunk of peach (*Prunus persica*) and related species. Upon hatching, larvae enter the tree (usually at or below ground level) and feed beneath the bark. Young trees may be killed, while older ones suffer reduced vigor. In conventional orchards, control is based on broad-spectrum residual insecticides applied to the trunk to kill newly-hatched larvae before they enter the wood. The lack of organically-approved insecticides with prolonged residual activity makes this a challenging pest for organic growers to manage. To address this issue, we conducted three years of field trials at two sites in New Mexico using two different approaches: soil and trunk applications of entomophagous nematodes (*Steinernema feltiae* and *Heterorhabditis bacteriophora*), and mating disruption with a commercial pheromone product (Isomate®-PTB Dual). Three trials were conducted with a mixture of the two nematode species (approx. 150,000 of each per tree), applied either once in late-summer or three times during the growing season. The nematodes were applied as a soil drench in a 15 cm wide band around the base of the trunk. An additional 30,000 nematodes of each species were applied as a trunk spray. None of the nematode treatments had a significant effect on *S. exitiosa* infestations. The pheromone product is not normally recommended for the small-scale peach orchards that are typical of New Mexico. However, we tested it in a very small peach block (approx. 0.05 ha) from 2010-2011. The dispensers (plastic twist-ties) were deployed in early May at a rate of approx. 500 per hectare. After 1 year, the summer *S. exitiosa* infestation rate declined from an historic average of 40-50% to 13%. While not adequate by itself, the pheromone may form the basis of an integrated pest management strategy for organic growers.

Arthropod Responses to Understory Management in Organic Peach Orchards in Northern Utah

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Arthropod populations were monitored in response to 11 orchard-floor, nutrient, and weed management treatments established in two peach (*Prunus persica*) orchards (0.48 and 0.40 ha) in Kaysville, Utah. This research is part of a collaborative organic stone-fruit project that utilizes a whole-systems approach. Project goals include replacing conventional weed management, providing internal nutrient inputs, and facilitating the establishment of organic fruit production in Utah. Treatments are combinations of alleyway vegetation (legume and grass), tree-row mulch (weed-fabric, straw mulch, tillage, herbicide, paper mulch, and unmanaged), nutrient input (organic compost with or without legume clippings and commercial NPK), and management approach (conventional, organic, and transitional). Arthropods were sampled in alleyway plots by sweep-netting in 2010 and 2011. A total of 63,754 arthropods were categorized into 102 taxonomical groups and three functional groups (beneficial, pest, and neutral). Arthropod abundance responded to alleyway vegetation ($p = 0.03$). Analyses of least square means indicated a greater trap catch in legume than grass alleyways. Rarefaction curves (a measure of taxonomical diversity) were highest in legume plots. Treatments did not significantly increase pest arthropods such as cat-facing insects (e.g., *Lygus* sp.) which are a concern with legumes. The European earwig (*Forficula auricularia*) is of interest due to its abundance and diverse functional role (it is both an herbivorous pest and a beneficial predator). F-generation earwig populations were sampled weekly with two cardboard refuge-traps, placed on a single tree per plot from May through October. Date, treatment, and placement affected trap catch. Earwigs were more abundant in plots with legume alleyways. Traps placed in canopies caught more earwigs than those placed on trunks suggesting that earwigs spend significant time in trees. Legume alleyways may provide benefits such as enhanced tree growth and

arthropod diversity, but risks such as greater earwig abundance need to be considered in the overall system analysis.

Insect Biocontrol – Abstract Accepted but not Presented

Emulsion Formulated with Micro-algae Oil as an Organic Insecticide on Cherry and Peach Trees

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Oil extracted from certain species of micro-algae (*Microcysis aeruginosa*) was formulated into an emulsion and the efficacy of this emulsion as an organic insecticide on cherry (*Cerasus pseudocerasus*) and peach (*Amygdalus persica*) trees was tested. Results showed that when applied before bud break, the oil emulsion at 0.1, 0.5, 1.0, 1.5, 2.0, 3.0, and 5.0% reduced aphid (Myzuspersicae) and red mite (*Tetranychus cinnbarinus*) populations in a concentration dependent manner. The 2% oil emulsion reduced aphid populations from 5/leaf to 0.1/leaf, and red mites from 3/leaf to 0.05/leaf. The 5% oil emulsion caused damage to newly emerged leaves, but no damage was observed when the oil emulsion was used at lower concentrations. When applied after bud break, the oil emulsion was more effective in controlling pests than when it was applied before bud break. However, phytotoxicity was more severe when it was applied after bud break. Leaf damage was observed when the oil emulsion concentration was 3% or higher on both peach and cherry trees.

Organic Pomegranate Production in Iran

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Pomegranate (*Punica granatum*), which has been cultivated from ancient times in the Middle East, originated from Persia and adjacent areas, with Iran being the first producer of this fruit in the world. Due to the long history of pomegranate cultivation in Iran, the production techniques are environmentally friendly and predominantly organic. The most serious problem in production is the pomegranate moth, (*Ectomyelois* (*Spectrobates*) *ceratoniae* Zeller, Piralidae), which lays eggs inside the crown on the fruit stamens. Worms enter the fruit from the crown area, which protects them from sprays. Therefore, control of this pest is done without the use of chemical sprays. Biological control with tiny Trichogramma wasps, which are moth egg parasitoids, as well as mechanical agricultural methods, are used to control this pest. The harsh climatic conditions (hot and dry weather), which are predominant in pomegranate production centers in Iran, is the main reason for lower incidence of pests and diseases on this fruit. Fertilization of pomegranate orchards is primarily farm manure, with chemical fertilization less common. The organic production of pomegranate, along with its valuable medicinal properties, makes it an attractive super fruit.

Concurrent Session 2A. Plant Pathology

Systems Approach to Fire Blight Control in Organic Pear and Apple without Antibiotics

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Pome fruit produced organically under the USDA National Organic Program (NOP) standard can be treated with streptomycin or oxytetracycline to suppress the fire blight bacteria (*Erwinia amylovora*), but a recent NOP regulatory review set 2014 as the phase-out year for these antibiotic materials. In response, we have employed a systems approach to study and develop non-antibiotic programs for fire blight control in the western United States. The objectives of this research are to: 1) understand the effects of sanitation (e.g., copper spray at the delayed dormant stage of growth) on pathogen presence in flowers, 2) quantify the impact of fruit thinning materials on pathogen and biocontrol agent populations in flowers, and 3) develop integrated biocontrol programs where registered products are applied at specific stages of flowering based on their relative ability to suppress the pathogen on the floral stigmatic surface or within the floral cup. Under Objective 1, the effect of sanitation on pathogen presence in flowers is being evaluated with a molecular scouting technique termed 'loop-mediated isothermal DNA amplification' (LAMP), which in the future could be available as an on-site decision aid. Experiments under Objective 2 demonstrated that some bloom-thinning materials (e.g., lime sulfur and fish oil) suppress bacterial growth in flowers, and therefore, shorten the time during bloom when other materials are needed for fire blight control. Under Objective 3, biocontrol programs beginning with stigma colonizers (e.g., gram-negative bacteria in Bloomtime Biological™ or BlightBan™) followed by floral cup protectors (e.g., the gram-positive bacterium in Serenade Max™ or yeast in Blossom Protect™) provided significant and consistent fire blight control, although an increased frequency of treatments of these biological materials was required to approach the levels of disease suppression of antibiotic treatments.

Introducing Blossom Protect: An Effective Alternative to Antibiotics for the Control of Fire Blight

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Westbridge Agricultural Products has been conducting university research trials over the past four years on a new biological product called Blossom Protect™. This plant protection product is used to control fire blight in pome fruit. Blossom Protect™ was granted EPA approval and organic certification from the Washington State Department of Agriculture in January 2012. Blossom Protect™ contains strains of the yeast *Aureobasidium pullulans*, which suppress the fire blight pathogen (*Erwinia amylovora).* Fire blight typically infects the tree via the blossoms during bloom and can rapidly damage entire trees if orchards are not preventatively protected. Blossom Protect™ inhibits growth of the fire blight pathogen through natural competition for space and nutrients on the blossom surface and within the nectaries. As Blossom Protect™ acts through competitive exclusion and does not directly attack the metabolism of the bacterial pathogen, there is no risk of the pathogen developing resistance, even with frequent applications. Therefore, it is an important tool in an anti-resistance management strategy. The strains of *A. pullulans* that are the active ingredients in Blossom Protect™ were isolated from apple (*Malus* x *domestica*) leaves. *A. pullulans* is ubiquitous and occurs naturally on many plant surfaces. Blossom Protect™ has been shown to aggressively colonize the nectary of flowers, thereby blocking the primary site for fire blight infection. Blossom Protect™ must be used with Buffer Protect™, a nutrient buffer which ensures the colonization of flowers by the *A. pullulans.* Blossom Protect™ has significantly reduced the incidence of fire blight across all trials when used at recommended rates and timings. A summary of the trial results will be presented and the use of Blossom Protect™ in integrated pest management systems will be discussed.

Effect of Spray Application Parameters on Viability of Bacterium *Pseudomonas fluorescens* Used as Bio-pesticide in Organic Fruit Production

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Strains of the bacterium *Pseudomonas fluorescens* antagonistic to the fungus (*Venturia inaequalis*) have potential to reduce severity of scab disease in organic apple (*Malus* x *domestica*) production. The viability of the bacterium during passage through different components of a spray application system is crucial to its capability to mitigate disease development. *P. fluorescens* can survive static pressures up to 300 MPa. However, little is known about its resistance to rapid and frequent changes of pressure, and other forces typical for spray application with orchard sprayers. Within the project EcoTechProduct, the test stand was developed with two independent liquid circuits to simulate the spray application of

bio-pesticide with two contrasting methods: 1) high-pressure system (1.5 MPa) with diaphragm pump, pressure control unit, and hydraulic hollow-cone nozzles; and 2) low-pressure system (0.25 MPa) with centrifugal pump, flow restrictor, and pneumatic atomisers. Sensors were mounted at the key elements of the liquid circuits to measure and record temperature and pressure. A suspension containing Ps49A strain of *P. fluorescens* was applied with each of the two application systems. Samples of the suspension were taken at different time intervals from the tank and then after passing through the system elements (pump, pressure control unit, filter and nozzles) they were evaluated for bacterium viability. At the high spray volume (450 l/ha) the viability of bacteria remained at a similar level for both the high- and low-pressure systems after 120 min of spraying. However, at the low volume (55 l/ha) the number of cycles of liquid passing through the pump that were used in the high-pressure system increased from 12 to 97 per hour, and the bacteria died after 60 min. Preliminary results showed that the major factor influencing *P. fluorescens* viability is the number of passages through the spray system circuit that the bacteria can endure.

Progress in Brassicaceae Seed Meal Formulation and Application for Replant Disease Control in Organic Apple Orchards

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Brassicaceae seed meals when used independently do not provide uniform or sufficient control of the pathogen complex that incites apple (*Malus* x *domestica*) replant disease. Trials were established at multiple sites (STM, SR and Tukey orchards) in Washington State, USA to evaluate the efficacy of seed meal formulations for control of this disease in organic production systems. Seed meal applications were conducted in the autumn prior to planting or in the spring of planting and tarped with a virtually impermeable film for a period of 7-10 days. Formulations composed of *Brassica juncea/Sinapis alba* (*Bj/Sa*) or *B. juncea/Brassica napus* (*Bj/Bn*) seed meal significantly improved apple tree growth and suppressed the target pathogen complex, composed of *Cylindrocarpon, Phytophthora, Pythium, Rhizoctonia* and *Pratylenchus* spp., at all sites over the initial two growing seasons. The *Bj/Sa* formulation was superior to *Bj/Bn* in promoting tree growth, but spring application of the *Bj/Sa* formulation to the low organic matter SR orchard soil caused significant phytotoxicity and approximately 40% tree death. At this same site, *Bj/Sa* seed meal application in the autumn prior to planting resulted in tree growth that was equivalent to that attained in response to pre-plant soil fumigation. Initial year tree growth was improved by *Bj/Sa* seed meal application at the Tukey orchard; however, significant rodent damage and additional unidentified factors resulted in significant tree mortality during the second year. At the STM orchard, application of *Bj/Sa* seed meal in the spring of planting provided superior disease control and tree growth relative to soil fumigation with 1,3-dichloropropene/chloropicrin, and reduced in-row weed coverage by approximately 85%, with weed suppression evident at the end of the growing season. These preliminary data indicate that the seed meal formulation may be as or more effective than non-organic, pre-plant soil fumigation for control of replant disease, but that plant back periods and seasonal application requirements will vary with soil type.

Management of Root Rot Disease of Blueberry with Gypsum and Compost

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Root rot disease of blueberry (*Vaccinium corymbosum*) caused by *Phytophthora cinnamomi* is becoming more prevalent as a consequence of widespread adoption of drip irrigation. This creates higher moisture content in the root zone, which is more conducive for disease development. Options for disease control under organic management are limited, focusing primarily on improved drainage. We evaluated soil amendment regimes for suppression of root rot disease of blueberry under greenhouse conditions in pots. Peat, yard debris compost, and dairy solids compost were compared with sawdust, which is the grower standard. Organic amendments were incorporated into sandy loam soil at 20% v/v. Each residue was evaluated alone and in combination with gypsum (calcium sulfate) added at 5% (v/v) of total soil volume. Control soil amendment treatments included: 1) no amendment, 2) no amendment plus conventional fungicide soil drench, and 3) gypsum only with no compost. We hypothesized that compost and/or gypsum would reduce *Phytophthora* root rot in blueberry. It has been shown that compost increases cellulase enzyme activity in soil and that cellulase is capable of degrading *Phytophthora* cell walls. Gypsum is thought to control root rot by calcium ion inhibition of *Phytophthora* zoospore motility and survival. In our first greenhouse trial, organic residues had no effect on *Phytophthora* infection, but gypsum suppressed the severity of infection. A second trial is in progress to confirm these results. Gypsum is likely a promising tool for managing root rot disease of blueberry in organic production systems.

Control of Bacterial Wilt in Organically Grown Muskmelon

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Bacterial wilt in cucurbits, caused by *Erwinia tracheiphila*, continues to challenge producers of high-value melons. Existing organic controls are physical exclusion or short-duration OMRI approved pesticide applications that focus on control of the vectors, striped and spotted cucumber beetles (*Acalymma vittatum* and *Diabrotica undecimpunctata*, respectively), rather than the pathogen. To improve production, a modification to the typical organic field production method that included row covers until anthesis and insecticides until harvest was tested on 'Athena' muskmelons (*Cucumis melo)*. The modified treatment returned fabric row covers to the crop after two weeks of pollination in order to exclude the vector for the remaining development/ripening stages. The treatment was found to provide similar results to typical production while reducing the need for pesticide application by over 50%, thus improving the profit margin. To further increase the effectiveness of the modified production method, a screening of potential natural plant defense, up-regulating substances identified the soil bacteria, *Pseudomonas fluorescens A506* (BlightBan® A506, Nufarm Americas, Inc.). The application of BlightBan® A506 on melon flowers during anthesis limited the spread of *E. tracheiphila* in the infected plant allowing the plant to fully develop marketable fruit. Results from laboratory, greenhouse and field applications of BlightBan® A506 to control *E. tracheiphila* provided further evidence of its efficacy. Test plots of 'Strike' muskmelon treated with BlightBan® A506 in a low-density vector year had no signs of phytotoxicity, produced yields similar to the typical organic practice, and had significantly reduced numbers of cull fruit. Further research to determine optimal application rates and formulation is necessary.

Effect of Bordeaux Mixture Spray on Fruit Quality of Grape cv. 'Kyoho' and Copper Accumulation in the Soil

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The table grape (*Vitis vinifera* hybrid) cultivar 'Kyoho' is grown on 2,730 ha, the second largest cultivar by area in Korea. This tetraploid cultivar is very susceptible to downy mildew (*Plasmopara viticola*). Many farmers are interested in growing this cultivar under organic management, but this is difficult due to high temperatures and humidity in the summer that lead to challenging disease problems. Thus farmers often make many applications of fungicides and other organic materials such as Bordeaux mixture. Bordeaux mixture has been effective in preventing downy mildew in Korean vineyards. Bordeaux mixture is composed of lime and copper, but copper is very toxic to many soil organisms. The European Union (EU) has limited the amount of copper used by organic growers to 6 kg ha^{-1} yr^{-1}, but the Korean Ministry of Environment just established an agricultural soil contamination standard of 50 mg Cu kg^{-1} soil. Some grape growers also enclose the grape bunch in a coated paper bag to help prevent waterborne disease and to keep dust and spray residues off the fruit. We investigated residual copper levels in soils of Korean vineyards with different Bordeaux mixture spray programs. In all 25 vineyards tested, copper levels were below the 50 mg/kg standard. However as the number of sprays increased, the residual copper level also increased. Grape quality was improved in many Bordeaux mixture treated blocks, because most leaves remained uninfected. Grape bunches without paper bags had poor appearance (which reduces the market price) and elevated copper levels in the grape juice. The residual copper in the soil did not reach the soil contamination standard, but copper concentration in the naked bunches sprayed with Bordeaux mixture was close to the permissible level of 20 mg/kg fruit for table grapes.

Plant Pathology - Poster Session

Development of a Real-Time PCR Assay for *Erwinia tracheiphila*

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Bacterial wilt in cucurbits, caused by *Erwinia tracheiphila*, is a xylem-colonizing pathogen that causes wilt by plugging the xylem to the point of occlusion with plant fluids, thereby causing distal wilting and eventual plant death. Interplant pathogen transmission occurs by the vectors striped and spotted cucumber beetles (*Acalymma vittatum* and *Diabrotica undecimpunctata*, respectively), feeding on melon leaves and stems. Bacterial transmission from vector to plant occurs through mouthparts and frass deposition near feeding wounds on the plant. To improve laboratory capabilities for *E. tracheiphila* detection, a new real-time polymerase chain reaction (real-time PCR) assay was developed for rapid detection and quantification of the pathogen. A novel pair of primers (forward, 5'-GGACGGCGTATTTCTTTCAA -3' and reverse, 5'- CATCTTGACCGTTTTTGCTC-3') were designed to amplify a 161 bp portion of the carbomoylphosphatase synthetase gene, GenBank # DQ859839. Previous research successfully used this same gene for conventional PCR, however, not for real-time PCR. Further, a TaqMan probe (5'-CAGCTGCTGGCACTCGCCAG-3') complementing the primer set was also designed to enhance identification and quantification. Detection of the amplicon using SYBR Green was also successfully documented. Laboratory testing was conducted on 'Athena' muskmelons (*Cucumis melo*), and this primer set was able to detect *E. tracheiphila* in melon plant tissue samples. Specificity of this primer set was confirmed in tests against closely related pathogens and other microbes that are closely associated with *E. tracheiphila* in melon plants, further indicating the usefulness of this method for detection purposes.

Strategic Irrigation against Apple Scab

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In Denmark there are organic apple (*Malus* x *domestica*) orchards where no foliar sprays are applied and non-spray methods are sought to prevent apple scab (V*enturia inaequalis*). In this trial, strategically applied irrigation was tested to prevent scab infection. During April-June 2011, five organic orchards were irrigated on the orchard floor to force the discharge of ascospores from the pathogen. At least 0.2 mm of water was applied during dry periods at least 12 hr before rain was forecast. The hypothesis was that ascospores released under dry conditions would desiccate without infecting the leaves. The best strategic timing for irrigation was determined using local weather forecasts and the scab-warning program Rimpro, based on data from meteorological stations located in the orchards. In the first year of the trial we experienced difficulties in spreading the water evenly on the orchard floor. A water wagon provided better results than sprinklers in evenly distributing the water. We found that these strategic irrigation applications did result in ascospore release, but there was no significant effect on the scab infection. Local fruit growers found this method for controlling apple scab interesting and easy to follow. This trial was financed by Fonden for Oekologisk Jordbrug and will continue in 2012 and 2013 in cooperation with the University of Copenhagen.

Biological Control of Phacidiopycnis Rot in 'd'Anjou' Pears

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Phacidiopycnis rot, caused by *Phacidiopycnis piri*, is a recently reported postharvest fruit rot disease of pears (*Pyrus communis*) in the U.S. and a major disease of 'd'Anjou' pears grown in Washington State. Phacidiopycnis rot can originate from infection of wounds on the fruit. In this study, two biocontrol agents, BioSave (a *Pseudomonas syringae* strain) or *Cryptococcus laurentii* strain 87-108, compared to the conventional fungicide thiabendazole (TBZ) were evaluated for control of Phacidiopycnis rot. 'D'Anjou' pear fruit were surface disinfested, wounded with a finishing nail head, treated with one of the biocontrol agents or TBZ, and inoculated with conidial suspension of *P. piri*. A non-treated control was included with pathogen alone. The experiment was conducted twice using fruit from different orchards where no fungicides were used. Each treatment contained four 20-fruit replicates. Inoculated fruit were placed on fiber fruit trays wrapped with perforated bags and stored in cardboard boxes at 0°C for three months, at which time decay was assessed. Over 92% of the fruit in the non-treated control developed Phacidiopycnis rot. BioSave and *C. laurentii* significantly reduced incidence of Phacidiopycnis rot by 96-98% and 38-45% compared to the control, respectively. BioSave was more effective than the *C. laurentii*. No decay was observed on TBZ treated fruit, but there was no statistical difference in decay incidence between BioSave and TBZ treatments. The results suggest that BioSave is effective in controlling Phacidiopycnis rot originating from wound infections by *P. piri* and can provide a level of control of Phacidiopycnis rot comparable to that of TBZ.

Assessment of Kelp Extract Biostimulants on Disease Incidence and Damage in a Certified Organic Apple Orchard

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Organic farmers commonly use natural biostimulants in their fertility program to supplement mineral nutrition. These materials are a poorly defined group of products that are not classified as plant fertilizers, but when used in small quantities may improve plant growth or function. In 2009 and 2010, two biostimulant materials, Stimplex® and Seacrop16™, extracted from kelp (*Ascophyllum nodosum)*, were applied as horticultural treatments and tested against a non-treated control in a certified organic apple (*Malus x domestica*) orchard in South Burlington, VT. The objective of this study was to assess non-target effects from application of these kelp extract biostimulants on incidence of disease symptoms on foliage and fruit. Kelp extracts were foliarly applied at labeled rates seven times during each growing season to each of five replicates of the cultivars 'Ginger Gold', 'Honeycrisp', 'Liberty', 'Macoun', and 'Zestar!'. Treatments were applied in a completely randomized design and the same treatment was applied to the

same trees in both study years. Data were analyzed with a two-way ANOVA with separate cultivar and kelp extract treatments, and Tukey's HSD was used to test mean separations among treatments. The majority of the results indicate no effect of kelp extracts on disease incidence on foliage or fruit. However, reduced incidence of powdery mildew on 'Ginger Gold' was observed for both kelp extract treatments in 2009 versus the non-treated control, and incidence of fruit rots was greater for 'Honeycrisp' treated with kelp extract in 2009.

The Effect of Hydrogen Peroxide on Powdery Mildew Control of Melon

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Powdery mildew (*Podosphaera xanthii*) is a serious problem in production of organic musk melon (*Cucumis melo*). The disease affects plant photosynthesis and degrades fruit quality. Eco-friendly powdery mildew control practices were evaluated during April-August on commonly grown musk melon varieties in Korea's south Jeollabuk-do Province. Various concentrations of hydrogen peroxide (0.1%, 0.2% and 0.5%) and egg yolk oil were applied as foliar sprays for control of powdery mildew. Hydrogen peroxide inhibited the occurrence of the pathogen and suppressed powdery mildew, and also increased the tolerance of plants to high temperatures. A 10% yield increase in fruit production was observed in the plants treated with 0.5% hydrogen peroxide compared with the non-treated control. In addition, sugar content in the fruit was improved when plants were treated with the 0.5% hydrogen peroxide spray.

Disease and Arthropod Evaluation of Five Apple Cultivars under Organic Management in Vermont, USA

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The small number of certified organic apple (*Malus* x *domestica*) orchards in the New England region, USA, reflects the arthropod management and horticultural challenges of organic apple production and the disease challenges associated with the traditional cultivar grown in the region (i.e., 'McIntosh'). However, recent shifts in consumer preference for 'newer' cultivars has led to the planting of different apple cultivars in New England which have different disease susceptibilities, and research has identified potential alternatives for arthropod and horticultural obstacles in organic apple production. Growers want to know what the potential is for sustainable and profitable organic apple production with the newer cultivars being planted. The objective of this research was to evaluate differences in arthropod and disease incidence among five cultivars that were identified as important to the future of the apple industry ('Ginger Gold', 'Honeycrisp', 'Liberty', 'Macoun', and 'Zestar!') within the two major orchard systems growers are using to change to new cultivars: (i) a new orchard planted with young trees purchased from a nursery and (ii) a "top-grafted" orchard, i.e., an established, older orchard onto which new cultivars are grafted. Disease symptoms and arthropod infestations and/or damage were evaluated on foliage during the growing season and on fruit at harvest for three years, 2009-2011, in these two types of orchard systems which were under organic management and organically certified. Differences were detected among the five cultivars for certain diseases and arthropod pests.

Concurrent Session 1B and 2B. Horticulture

Performance in the Early Production Years of Two Organic Orchards Established by Different Methods: Top-grafting and Newly Planted

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Since 2006, the OrganicA Project has been evaluating the performance of five apple (*Malus* x *domestica*) cultivars, 'Ginger Gold', 'Honeycrisp', 'Liberty', 'Macoun', and 'Zestar!' under two orchard establishment methods growers use in changing cultivars: top-grafting, and establishing a new orchard with nursery trees on dwarf rootstock. The top-grafted orchard, Orchard 2, was originally planted in 1988 with the cultivars 'Liberty' and 'McIntosh' on M.26 rootstock on free standing trees at a density of 716 trees/ha. In 2006, the orchard was grafted to the five new cultivars. The new orchard, Orchard 1, was planted in 2006 in a completely randomized design with 15 three-tree replicates per cultivar. Planting stock was one year-old nursery trees on B.9 rootstock, except 'Honeycrisp', which was on M.26, planted at a density of 1433 trees/ha and supported by a 2.4 m tall single-wire trellis. Orchard 2 uses a randomized complete block design with a total of eight and eleven replications in block 1 and block 2, respectively. The blocks relate to the original cultivar (i.e., 'Liberty' = block 1, 'McIntosh' = block 2) which is now the interstem of each tree. In orchard 1, 'Ginger Gold' has generally exhibited better growth and fruit yield than the other cultivars, while 'Liberty' has been the poorest performer. For orchard 2, tree survival has been poorest for 'Macoun' and 'Zestar', while 'Ginger Gold' has shown increased harvested fruit yield over 'Liberty' and 'Macoun'. Results suggest top-grafting may be an economical and sustainable technique to change existing apple cultivars, but performance is cultivar dependent and several years may be necessary to determine its success or failure.

High Tunnels and Annual Growing Systems for Organic Strawberry Production in Three Diverse Environments

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Many consumers prefer organic strawberries (*Fragaria sp.*), but organic growers must contend with erratic seasonal production, fruit molds and other diseases. To address these problems, we established experimental trials within three diverse climates: 1) Knoxville TN (humid, subtropical), 2) Lubbock TX (semi-arid, steppe), and 3) Mount Vernon WA (dry-summer subtropical/oceanic). At each location, June-bearing and day-neutral cultivars were planted October 2009 and September 2011 for harvest in 2010 and 2011, respectively. Plants were grown in an annual system with black plastic mulch, in both open field (OF) and High Tunnel (HT) locations. Four-season HT's were used at Knoxville and Lubbock, and remained in place for the duration of the experiments. The polyethylene film covers of the three-season HT's used at Mount Vernon were taken down in late October, and were not replaced until the following April. Organic production practices were utilized at all locations except at Lubbock in 2011 when two applications of environmentally-soft fungicides were used to control *Botrytis* and three insecticide applications were made to control spider mites and thrips. The HTs increased marketable yields at Knoxville (2010 and 2011) and at Lubbock (2011), and were essential to marketable strawberries at Lubbock where seasonal high winds severely damaged

plants and fruits in OF, and rendered them unmarketable. In 2011 in Knoxville, OF plants were severely damaged by a hail storm rendering the fruits unmarketable. HTs substantially reduced losses to *Botrytis* fruit rot at Knoxville (2011) as well as at Mount Vernon (2010, 2011). However, HTs also significantly increased plant collapse due to *Verticillium* at Mount Vernon in 2010, presumably because of increased soil temperatures. June-bearing cultivars were most productive at Knoxville and Lubbock, producing fruit in December and from April through June at Knoxville, and at Lubbock from late November to mid-December as well as April through June. In contrast, day-neutral cultivars were the most productive in the relatively cool environment of Mount Vernon, where they produced fruit from June through October both years. Plug plants of 'Albion' produced higher marketable yields compared with bare root plants, more than compensating for the higher cost of the plugs. HTs and annual growing systems made organic strawberry production feasible over a wide range of climates. However, to be successful, appropriate cultivar and tunnel construction choices need to be made according to location.

High Tunnel Production of Organic Strawberry grown on Raised Gutters: Effects of Fertilization Management on Three Cultivars

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High tunnel production systems are gaining in popularity in eastern Canada to extend harvest until October, increase yield, limit pathogen damage, and improve the quality of fruits and vegetables. However, very little research has been conducted to evaluate the season extension benefits and profitability offered by high tunnels for organic fruits. The fresh market for organic fruits is dominated by the United States, particularly California, where ideal growing conditions extend the harvest season. The purpose of this study was to develop an organic growing system under high tunnels for day-neutral strawberry (*Fragaria* × *ananassa*) cultivars in eastern Canada. To test the effect of fertilization and soil management on different cultivars, a split-plot experiment with four replicates was performed at Les Fraises de l'Île d'Orléans (St-Laurent d'Orléans, Québec). The effects of two fertilization regimes combined with two organic growing mediums on soil mineral content, plant growth, yield and fruit quality were determined. The four treatments were: 1) organic liquid fertilisation with an organic growing media, 2) organic solid and liquid fertilisation with an organic growing media, 3) conventional nutrient solution with an organic growing media, and 4) conventional nutrient solution with a conventional growing media. The three cultivars ('Seascape', 'Charlotte', and 'Monterey') were subplots in the experiment. Plants were transplanted into 3-liter containers and watered with a drip irrigation system. In general, fertilization and growing media treatments had no significant effect on total yield and fruit size. The harvest period under high tunnels was extended by 4 weeks compared to an adjacent field crop. Under the organic and conventional regimes, the productivity of 'Seascape' was 40% higher than 'Charlotte'. Fruit dry matter of 'Charlotte' was lower under the organic regimes compared to the conventional control. Results will also be discussed in terms of nutrient availability, as well as the profitability of this high-tunnel growing system for organic strawberry.

Effects of Weed and Nutrient Management Practices in Organic Pear Orchards

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From 2009-2011, four weed control treatments (in-row mowing, landscape fabric, wood chips, and organic herbicide) and three fertilizer treatments (poultry manure at high vs. low rate, and feather meal) were compared in an organic, untilled 'Bosc' pear (*Pyrus communis*) orchard with solid-set sprinklers. Weed control in the landscape fabric and wood chip treatments was generally excellent, and multiple herbicide applications per year resulted in only partial control. There were no significant yield differences among treatments, and little difference in fruit diameter or weight. There were no significant differences in trunk growth among treatments. The wood chip treatment had significantly lower stem water potential than other treatments in August 2009 only. In two of the years, the N content of leaves in mow + no fertilizer was significantly lower than most high-rate manure treatments, and leaf P content followed the opposite trend. All fertilizer treatments tended to increase soil nitrate-nitrogen over non-fertilized plots. Soil phosphorus and potassium were highest under wood chips, and phosphorus was lower under feather meal. Soil pH was lowest under feather meal, and soil organic matter was highest under wood chips. Wood chips tended to have fewer vole holes than in-row mowing, and fabric resulted in slightly greater trunk damage by voles. Assuming that landscape fabric lasts 8 years, it is only slightly more expensive per year than in-row mowing alone. An organic herbicide program is more expensive because of the herbicide cost and the many applications required. Wood chips were by far the most expensive treatment because of their procurement and application costs, as well as the need to re-apply them every year. The use of feather meal was about three times the cost of low-rate manure application for an equivalent amount of N, but poultry manure is sometimes unavailable.

Effect of Organic Fertilizers on Photosynthetic Efficiency of Strawberry Plants

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In an effort to elucidate the mechanisms of action of organic fertilizers and amendments on plant metabolism, the effect of organic fertilizers produced from different raw materials on chlorophyll content and fluorescence was studied. Strawberry (*Fragaria* x *anannassa* 'Elsanta') plants grown under field conditions were treated with either: 1) dry manure alone (control), 2) dry manure in association with seaweed extract (BFQuality), 3) vermicompost extract (Humus UP), 4) exhausted yeast production culture broth derived from sugar beet molasses (Vinassa), and 5) a microbial mixture composed of mycorrhizal fungi and plant growth promoting rhizobacteria (Micosat). Two control treatments of standard chemical NPK fertilization and an unfertilized treatment were also included in the experimental design. Chlorophyll fluorescence was measured by a chlorophyll fluorimeter, together with chlorophyll index measured with SPAD meter. Total leaf N, NO_2, and NO_3 concentrations were also determined. Photosystem II (PSII) efficiency was significantly affected by the treatments and changes were observed for various chlorophyll fluorescence parameters. Changes in the content of the different forms of N in leaves were also recorded: a several-fold higher N, NO_2, and NO_3 concentrations were found in chemically fertilized strawberry plants compared to organically fertilized plants. These results will be discussed with reference to nitrogen availability from different organic inputs and its effect on the efficiency of primary metabolic pathways.

Transition to Organic Fruit Production: Impact on Yield and Environmental Performance of Muscadine (*Vitis rotundifolia*) in a Heavy Soil

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Increased concerns with environmental quality have stimulated farmer interest in organic farming. Muscadine grapes (*Vitis rotundifolia*) are native to the southeastern United States and have been cultivated for over 400 years. In our 10-year experiment, 'Summit' muscadine grapes were grown at 6.08m x 6.08m spacing on Memphis silt loam soil (Typic, silty, mixed,

thermic Hapludalph) with different organic manures and forest waste. Three treatments of organic manures (cow-C; poultry-P; cow+poultry-CP) with pine mulch were applied annually, with rates based on soil tests, in basins around each plant in a completely randomized design for 10 years. A control treatment received regular inorganic fertilizers and traditional cultural practices (i.e., without mulching and mowing around the vines) but with no inorganic chemicals used to prevent pests or diseases. Leaf area index, percent canopy cover, stem diameter, and yield were higher in organic plants. There was no significant difference in size and soluble solids (^{o}Brix) of the fruit. No coliforms, yeasts and molds, or any other pathogenic organisms from organic manures were found on the grapes. Soil compaction was always higher in the control, along with lower soil moisture content. Compaction was lower in organic treatments due to higher levels of organic matter buildup. Concentrations of nitrate-N and P were higher in the surface soil, but there was no trend in N or P enrichment in lower layers of the soil. Fruit yields during transition were 4475, 5886, 6531, and 5271 kg ha^{-1} for poultry, cow, cow+poultry, and NPK, respectively. Fruit yield of organic plants continued to be higher after the transition period and lowest in the control. No study was conducted on the effect of mulch on manure, but mulched plant basins did not have weeds. The results suggest that the controlled application of manures in basins of muscadine grape vines can be an agronomically and environmentally sound practice.

Assessment of Kelp Extract Biostimulants on Tree Growth, Yield, and Fruit Quality in a Certified Organic Apple Orchard

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Reduced tree vigor and fruit yield are frequent challenges experienced in organic apple (*Malus* x *domestica*) production. To address these issues organic farmers commonly use natural biostimulants in their fertility program to supplement mineral nutrition. These materials are a poorly defined group of products that are not plant fertilizers, but which when used in small quantities are purported to improve plant growth and/or function. In 2009 and 2010, two biostimulant materials extracted from kelp (*Ascophyllum nodosum*), StimplexÒ and Seacrop16^{TM}, were foliarly applied and assessed against a non-treated control in a certified organic apple orchard in South Burlington, Vermont USA. The objective of this study was to assess effects from application of kelp extract biostimulants on tree growth, crop yield, and fruit quality. Kelp extracts were applied at labeled rates seven times during each growing season to each of five replicates of the apple cultivars 'Ginger Gold', 'Honeycrisp', 'Liberty', 'Macoun', and 'Zestar!'. Treatments were applied in a completely randomized design and the same treatment was applied to the same trees in both study years. Data were analyzed with a two-way ANOVA with separate cultivar and kelp extract treatments, and Tukey's HSD was used to test mean separations among treatments. Most of the data showed no effect from kelp extracts on tree growth, crop yield, and fruit quality. The StimplexÒ treated trees had increased tree height on 'Ginger Gold' in one study year, but reduced tree width on 'Macoun' in the same season. Kelp extracts had little effect on assimilated mineral nutrients in foliage. However, the Seacrop16 treated trees had reduced levels of some minerals. Both kelp extract treatments reduced incidence of sunburn and frost rings on fruit in 2010. Effects from application of kelp extracts on yield were not statistically significant, but observed differences may be of practical interest to commercial growers

Effect of Bio-Fertilizers and Soil Conditioners on the Quality of Apple Maiden Trees

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Production of maiden (one year old) trees under organic management is considered difficult due to the high nutrient supply required to obtain trees of good horticultural quality. Maiden apple trees (*Malus* x *domestica*) 'Topaz' and 'Ariwa' grafted on M.26 rootstocks were produced with the use of several bio-fertilizers and soil conditioners of different origins: 1) a seaweed extract; 2) a combination of mycorrhizal fungi and plant growth promoting rhizobacteria; 3) vermicompost extract; and 4) stillage from yeast production. The quality of the trees was compared to those treated with organic animal manure, standard NPK, or with no fertilization. The amount of nutrient elements delivered with the organic products was 50 to 70% lower than that provided by the manure or NPK fertilization. Application of the different bio-fertilizer products and soil conditioners generally resulted in maiden trees with trunk diameter, tree height and leaf chlorophyll index greater than or similar to the manure and NPK fertilized controls. Several products also induced an increase in branching and lateral shoot length of the maiden trees. The results confirm that these bio-fertilizers and soil conditioners can provide maiden apple trees with an adequate nutrient supply, and therefore could be utilized successfully in organic apple nurseries.

Mechanized String Thinners, An Effective Tool for Cropload Management in Organic Apricot Production

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Fruit size is the price driver in the U.S. commercial stone fruit market. North American organic stone fruit producers have very few registered chemical thinners and none that are effective or reliable. Thinning strategies are either 1) hand thin or rake at bloom with follow up at green fruit stage; or 2) hand thin at green fruit stage. Both thinning operations are expensive and depend on the availability of large numbers of orchard workers. Studies were conducted to optimize one commercial and one prototype string thinner under commercial field conditions. Replicated trials were designed to evaluate the effectiveness and economic impact of the mechanical string thinners in organic apricot (*Prunus armeniaca*) production. Field trials were conducted in 'Robada' and 'Goldbar' apricot orchards in 2009, 2010 and 2011. The 2009 treatments evaluated spindle speed, cord number and arrangement on the Fruit Tec Darwin string thinner at bloom versus hand thinning at bloom. The 2010 treatments included the Fruit Tec Darwin operating at 4.8km/h, 217 spindle rpm and 4 spines at bloom and hand thinning at bloom. The 2011 trials included three treatments: 1) the Darwin at above operating parameters; 2) the WSU hand-held thinning device at bloom; and 3) hand thinning at green fruit stage. Bloom thinning by hand or with mechanical bloom thinners is effective at removing bloom and increasing fruit size in 'Robada' and 'Goldbar' apricot. The Darwin and WSU hand-held thinner are effective mechanical bloom thinners. Bloom thinned fruit had the highest proportion of fruit in the first pick timing of the multiple pick harvest. In these trials, hand bloom thinning costs ranged from $1300-1800 per hectare. Thinning with the Darwin costs $125-150/ha and $650/ha with the WSU hand-held thinning device.

The OrganicA Project: Research on Weed Management Options for Organic Apple Production

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Although there is significant interest in organic production, there are very few organic apple (*Malus* x *domestica*) orchards in New England, in part

because of production challenges such as effective, sustainable organic weed management. Few cost effective options are available. As part of the OrganicA Project, research was initiated in an organically-managed orchard ('Honeycrisp' and 'Snowsweet®' on M.26 rootstock, planted in 2007) in Maine to evaluate four weed management strategies imposed in 2009 and continued into 2011: 1) periodic mowing and herbicide applied once in 2010 and 2011; 2) herbicide applied twice each year; 3) herbicide applied three times; 4) bark mulch applied once in 2009; and 5) bark mulch applied once in 2009 with herbicide applied before application and again in 2011. Treatment 1 was intended to be an untreated control, but herbicide was accidentally applied once in 2010 and 2011. The herbicide GreenMatch™ (active ingredient d-limonene) was applied at the labeled rate in a one-meter band under the trees. Bark mulch was also applied in a one-meter band. Mulch resulted in the greatest duration of weed biomass reduction followed by herbicide applied three times. Soil moisture tension was highly variable in this unirrigated orchard and was occasionally lower in mulched plots and with herbicide applied three times compared to other treatments. Midday stem water potential did not differ among treatments, but was measured only 3-4 times each season. Mulch increased foliar levels of potassium in 2010 and 2011, manganese in 2010, and zinc in 2011 compared to herbicide applications. Foliar levels of nutrients were similar among the different herbicide treatments in both years. Weed management method did not affect the amount of bloom or yield. Trunk cross-sectional area was greater with mulch compared to herbicide, but no difference occurred between the different herbicide treatments or between the mulch treatments.

New Apple Cultivars for Organic Fruit Production in Northern Germany

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A key provision of EU organic legislation, also found in the rules of the different marketing labels for organic production in Germany, is to choose plant species and cultivars which are resistant to diseases and adapted to local conditions. This helps to avoid or reduce the amount of plant protection pesticides needed to achieve a healthy tree and a high quality fruit product. Disease resistance in apple (*Malus* x *domestica*) is focused on four main diseases: apple scab (*Venturia inaequalis*), apple canker (*Nectria galligena*), bitter pit (*Neofabraea perennans*), and apple mildew (*Podosphaera leucotricha*). The farmer organization for organic fruit growing in Germany decided at their annual meeting in 2011 to publish a recommendation for their members to use 20-30% resistant apple cultivars in their individual farm replanting programs. Several new cultivars have been tested in the variety testing department of the ESTEBURG fruit research, advisory and education center in the last 10 years. Prior to 2011, the advice for resistant cultivars was restricted to the well-known cultivars `Santana´ and `Topaz´. The latest results in variety testing (yield, fruit quality, taste), partly done under organic management, of disease resistant apple cultivars in northern Germany with cultivars named 'Dalinbel', 'Gaia', 'Galiwa', 'Merkur', 'Natyra', 'Opal', 'PRI 037', 'Renoir' and 'Sirius' provide encouragement that there will be more choices for the organic fruit farmer as well as for the consumer.

Characterization of Berry Quality of *Ribes nigrum* in Relation to Harvest Timing and Cultivar

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Consumers are constantly looking for new functional foods to incorporate into their diet. With that in mind, Prince Edward Island (PEI), Canada, farmers have started growing black currants (*Ribes nigrum*) to capture this market because studies suggest that black currants may provide protection from certain cancers, cardiovascular diseases, type II diabetes, obesity, and age-related macular degeneration. These health benefits are provided by anthocyanins, a water-soluble pigment found in black currants. Black currants have never been grown commercially in PEI, so research on production practices and their effects on berry yield and quality is needed. Like most specialized fruit, growing organic black currants for large scale production requires specialized knowledge of factors that can affect berry quality. Understanding factors that can influence berry qualities like anthocyanins is important if growers intend to market their product as a functional food item. We studied how berry quality is affected by cultivar choice, harvest timing and site effect under PEI conditions. The berry qualities of interest were size, juice pH, titratable acidity, total soluble solids (measured as % TSS), total antioxidant capacity, total phenolic content and anthocyanins. Seven cultivars were established in a randomized block design including: 'Titania', 'Blackhome', 'Ben Alder', 'Ben Connan', 'Ben Sarek', 'Ben Tirran', and 'Whistler' with two harvest timings, each replicated three times as separated plots with five plants per plot. The effect of harvest timing on berry quality characteristics of 'Titania' was examined on two sites at four different harvest timings. Site effects are being measured on Titania growing on five separate farms. Preliminary results suggest differences in the quality of berries harvested at different times and among different cultivars. These factors could be important in farmer cultivar selection and harvest management.

Recent Postharvest Developments in Organic Fruits: The Good, the Bad, and the Debatable

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This presentation will provide an overview, with examples, of some recent developments related to organic fruits after they are harvested. In general, this overview also applies to organic vegetables. *The Good*: There is an assumption, somewhat justified, that organic postharvest methods to control pests and maintain product value are not effective enough. However, there is now evidence that some organic postharvest methods are not only being successfully adopted by the organic fruit industry but also by the non-organic industry as well. A recent example would be the total replacement of the postharvest pesticide, diphenylamine (DPA), by the apple industry in Italy using organically-acceptable methods. *The Bad*: There is an incorrect, and potentially dangerous, assumption that organic postharvest methods for controlling pests, by definition, are safe for humans and the environment. The development and eventual withdrawal of the EPA-approved and OMRI-approved biocontrol fungus, *Muscodor albus*, will be discussed as an example of the fallacy of this assumption. *The Debatable*: There is an on-going debate about the nutritional value and safety of organic fruits (and vegetables). Some of the most contentious aspects will be discussed and critiqued. The critique will question the relevance of the debate, the validity of the information being quoted and illustrate how horticultural factors need to be incorporated if the debate is to progress beyond rhetoric.

Horticulture - Poster Session

Response of Blackberry Cultivars to Fertilizer Source in an Organic Production System

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The effect of fertilizer source on growth, yield, and quality of four blackberry (*Rubus* sp.) cultivars is being evaluated at an organic grower cooperator site established in 2010 in Jefferson, Oregon, USA. Three fertilizer treatments (acid-stabilized, liquid fish fertilizer blend; pelletized soybean meal; and pelletized, dried poultry manure) were applied in spring 2011 at a rate of 56 kg N/ha to early- ('Obsidian'), mid- ('Marion' and 'Black Diamond'), and late-season ('Triple Crown') blackberry cultivars. Our goal was to determine whether nutrient release rate and plant uptake varied based on the source and physical properties of the fertilizers used, and if this was evidenced by variations in plant nutrient status, plant growth, crop yield, and fruit quality among the cultivars. Data on plant growth (cane length and number), soil nutrient status pre- and post- fertilizer application, leaf tissue nutrient concentration, yield, fruit weight, percent soluble solids,

and firmness were collected. Botrytis fruit rot reduced fruit quality of early-season 'Obsidian', but two applications of fungicides approved for organic production (active ingredients: *Bacillus subtilis* and *Streptomyces lydicus*) reduced incidence of fruit rot in 'Triple Crown'. Our first year results showed that pelletized poultry manure reduced the pH and increased total acidity of 'Triple Crown' at early-, mid- and late-harvest. Pelletized poultry manure also reduced percent soluble solids compared to the other fertilizer treatments in early-harvested 'Triple Crown' and 'Obsidian'. A similar reduction in percent soluble solids occurred in late-harvested 'Triple Crown' fertilized with fish. Pelletized soybean meal reduced firmness of 'Triple Crown' fruit particularly on early harvest dates. Results for crop yield, berry weight, and fruit quality will be presented.

Water, Weed, and Nutrient Management Practices in Organic Blackberries

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The purpose of our study was to investigate the effects of organic management on plant and soil water and nutrient relations, plant growth, crop yield, and fruit quality in an organic trailing blackberry (*Rubus* sp.) production system. The split-split experimental design included two cultivars ('Marion' and 'Black Diamond'), two irrigation regimes (post-harvest and no post-harvest irrigation) three weed management treatments (landscape fabric or weed mat, hand-hoed, and non-weeded), and two primocane training dates (August and February). The 0.4 ha planting was established in May 2010 in Aurora, Oregon USA. Plants were not cropped in 2011. Irrigation was scheduled based on weekly readings of leaf water potential and soil water content. In 2011, plants with weed mat required up to 30% more irrigation water to maintain the same water potential as those in hand-weeded and non-weeded plots, particularly for 'Marion', which often had lower leaf water potentials than 'Black Diamond'. To date, there has been no significant effect of weed management practices on plant nutrient status, although 'Marion' tended to have a lower leaf N concentration in non-weeded plots. Soil pH was higher in non-weeded plots than under weed mat in 2010, but not in 2011. Overall findings to date suggest that weed management may directly affect soil and plant nutrient status. In 2012, we will begin to ascertain the effects of weed management, as well as post-harvest irrigation and primocane training date, on plant growth, crop yield, and fruit nutrient concentration.

Organic Blueberry Production Systems: Management of Plant Nutrition, Irrigation Requirements, and Weeds

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A long-term systems trial was established to evaluate management practices for organic production of highbush blueberry (*Vaccinium* sp.). The factorial experiment included two planting bed treatments (flat and raised beds), two fertilizers and application rates (feather meal and fish emulsion fertilizers each applied separately at 29 and 57 kg N/ha), three weed management treatments (sawdust mulch, compost topped with sawdust mulch, or weed mat), and two cultivars ('Duke' and 'Liberty'). The planting was established in October 2006 and was certified organic in 2008. Yields from 2008-2011 averaged 4.4 t/ha higher on raised beds than flat ground. Cumulative yield was also greater with feather meal than fish emulsion fertilizer in 'Duke', but similar regardless of source and rate of fertilizer applied in 'Liberty'. Unlike feather meal, the higher rate of fish emulsion increased fruit firmness, soluble solids, and leaf N in both cultivars, but reduced fruit weight. Weed mat was the best option for weed management, in terms of weed presence and cost, while compost plus sawdust resulted in the most weeds and the highest cost. Crop yields, however, were similar for the weed mat and compost plus sawdust treatments, and both were higher in two of three years than sawdust mulch only. Soil temperature was as much as 4.5 °C warmer under weed mat than under sawdust and up to 1 °C warmer in raised beds than in flat ground. Plants with these treatments required more frequent or longer irrigation cycles to maintain the same soil water content as those on flat ground with sawdust mulch. So far, the best management systems for fruit production have been raised beds, feather meal or low rate of fish emulsion fertilizer, and weed mat or compost plus sawdust mulch, where plant growth and crop yield have been similar to conventional production systems.

Evaluation of Day-Neutral Cultivars for Organic Strawberry Production in Washington

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Day-neutral cultivars allow strawberry (*Fragaria* x *ananassa*) production over a 4-5 month period in the Pacific Northwest (PNW) and are increasingly important to strawberry farmers in Washington State. Appropriate cultivar selection is critical for organic producers who use system approaches to optimize yield, overall vigor and durability, pest resistance, and fruit quality. All available day-neutral cultivars have been developed and tested in other regions for conventional production systems, and their suitability for organic production under PNW growing conditions is untested. Ten cultivars were evaluated under certified organic conditions for two years at a research center for traits of yield, vigor, fruit quality, and flavor in the establishment year and the second "carryover" year. The five cultivars that seemed most promising in the trial at the research center were further evaluated for two years on four organic farms. 'Seascape' and 'Aromas' had the highest yields on farm, while 'Albion' and 'San Andreas' yielded approximately 60% of 'Aromas' yield. 'Albion' was the highest rated and 'Aromas' was the lowest rated cultivar for on-farm flavor. 'Aromas' had high vigor over two years and low damage from botrytis fruit rot (*Botrytis cinerea*), powdery mildew (*Sphaerotheca macularis)*, anthracnose fruit rot (*Colletotrichum acutatum*), and lygus bug (*Lygus hesperus*) overall. The results indicate that organic farmers must choose between plant durability, which influences yield, and flavor when selecting a day-neutral cultivar. A dedicated day-neutral breeding effort may be needed to address this lack of cultivars with both excellent durability traits and flavor under organic management in the region.

Selection and Utilization of Natural Pigments for Artificial Pollination of Organic Kiwifruit

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Artificial pollination has become one of the most essential practices in commercial kiwifruit (*Actinidia deliciosa, Actinidia chinensis*) cultivation to achieve stable cropping performance in Korea, even in organic production. However, the pigment 'Red #2' which is used in the process of artificial pollination is unacceptable because of its potential negative effect on human health. In addition, it is synthetically derived which disallows its use in organic production. In a search for an alternative pigment for use by organic growers, several native plants which are readily available in the kiwifruit production region were selected and tested as potential pigment sources for use in artificial pollination. Pigment-pollen mixtures were sprayed on female flowers with a hand pollinator. Pigments from the fruits

of *Rubus coreanus* and *Phytolacca americana* had no negative effect on kiwifruit (*Actinidia deliciosa* 'Matua') pollen viability, with germination rates of 82% and 91%, respectively, that were not different than the control (82% with 'Red #2'). Pollination using these native pigments led to 100% fruit set in open field trials in an 8-year old organic kiwifruit orchard (2 years of results with 'Hayward', 1 year of results with 'Haegeum'). At harvest, the average fruit size and fruit seed number with the natural pigments were not different from those of 'Red #2'. A simple procedure was developed for the growers to prepare their own pigments by steeping the raw macerated plant materials in water for 2 hr at 80-85°C. The resulting product can be stored in a freezer for up to one year. Use of these native pigments could be expanded to pollination of other organic fruit crops such as Korean pear and sweet persimmon.

The Effect of Organic Fertilizers and Amendments on N Metabolism in Strawberry Plants

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Increasing interest in organic strawberry (*Fragaria* sp.) production is a driving force behind new inputs of fertilizers and amendments based on an organic approach to plant nutrition. The efficacy of these products is frequently shown through increased yields or plant growth, but their mechanism of action is generally poorly understood. The effect of different organic fertilizers and amendments on plant growth, photosynthetic rate, nitrate reductase activity and N content of strawberry ('Elsanta') was studied. Plants grown in rhizoboxes were treated with dry manure alone (control) or in association with either seaweed extract (BFQuality), vermicompost extract (Humus UP), exhausted yeast production culture broth derived from sugar beet molasses (Vinassa), a titanium-containing product (Tytanit), or a microbial mixture composed of mycorrhizal fungi and plant growth promoting rhizobacteria (Micosat). Unfertilized plants and plants fertilized with a standard chemical NPK fertilizer were used as controls. Photosynthesis parameters were measured with a LI-COR infrared gas analyzer in association with chlorophyll index measured with SPAD meter. Measurement of the nitrate reductase activity was done via a colorimetric assay. Total leaf N, NO_2, and NO_3 concentrations were also determined. Plant growth was widely affected by the different inputs, particularly with regards to root biomass, which increased in all organic treatments in comparison to both the non-treated and standard NPK fertilization. Photosynthetic rates varied among treatments, with the highest rates measured in plants treated with the titanium-containing product and the stillage from yeast production. Nitrogenase activity was higher in fertilized plants in comparison to untreated ones, but not different when comparing the organic fertilizer treatments with NPK fertilization. On the other hand, the content of the various forms of inorganic N in leaves was about 1000-fold higher in NPK fertilized plants compared to organically fertilized plants. It appeared that organic fertilized strawberries had a higher N-use efficiency compared to chemically fertilized plants.

'Fuji' and 'Delicious' Apple Volatile Production during High CO_2 or Low O_2 Controlled Atmosphere Storage

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Apple (*Malus* x *domestica*) fruit contain many biochemical pathways that are differentially regulated by development and ripening, and these pathways produce numerous volatiles contributing to apple aroma. Volatile production reflects fruit physiological status, and characterization of volatiles released during storage may provide a means to assess fruit quality and stress. While applicable to conventional or organic fruit, monitoring fruit volatiles during storage may be particularly applicable for organic fruit for which synthetic chemicals that control postharvest disorders are unavailable. Our study examined the impact of high CO_2 and low O_2 controlled atmosphere storage on apple volatile production and disorder development. We monitored volatile production by 'Fuji' and 'Delicious' apples during long term controlled atmosphere storage at high CO_2 (0.5, 1.5, or 5.0 kPa; 1 kPa O_2) or low O_2 (0.2, 0.7, or 1.5 kPa; 1 kPa CO_2), respectively. Volatile compounds collected onto solid sorbent traps by sampling storage chamber headspace were analyzed using GC-MS. The resulting volatile production differed by cultivar, O_2 and CO_2 concentration, and storage duration. Ethyl esters and ethanol both accumulated at higher CO_2 or lower O_2 levels, with the ethyl esters accumulating more rapidly than ethanol. In 'Delicious' apple, production of several non-ethyl esters and alcohols decreased with decreasing O_2 levels. Core and cortex browning was observed in 'Delicious' apples stored at 0.2kPa O_2 at 6 and 8 months, while 'Fuji' apples stored at 5.0kPa CO_2 developed core browning and cavities during the first 60 days of storage. 'Fuji' apples stored at 1.5kPa CO_2 had higher accumulation of esters and alcohols compared with fruit stored at 0.5 or 5.0kPa. The results indicate metabolic responses to CO_2 and O_2 storage conditions that affect volatile production and disorder development occur during apple storage and that differential accumulation of volatile compounds in storage chambers is detectable.

Increasing Profitability with Organic Orchard Floor Management Alternatives

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Tillage is widely used in organic orchards in Washington State, but it may cause adverse effects on tree growth, yields, and fruit quality, as well as jeopardize organic certification in these low organic matter soils. To address these issues weed management trials were begun in four organic orchards [three apple (*Malus* x *domestica*) and one pear (*Pyrus communis* subsp. *communis*)] in 2009. Tillage (Wonder Weeder™), combinations of herbicide (Greenmatch EX™) and flame weeding, and woodchip and woven fabric mulches were tested. Mulching controlled weeds most effectively in 2010 and in one apple orchard in 2011 in which woodchip mulch was underlain with fabric. This latter treatment also had the greatest rodent damage. Herbicide without flaming was least effective. Mulching usually resulted in the highest yields and the most favorable soil and tree water status. Fruit size and quality did not differ among treatments. In the mature, commercial 'Gala' apple orchard, mulching returned more revenue than tillage or herbicide/flaming. Our preliminary conclusions are that shallow tillage may not impair profitability in mature orchards growing in fertile soils, with higher organic matter and satisfactory irrigation systems, because of its lower cost and better rodent control. Although surface feeder roots may be damaged the first year tillage is used, the root system should adapt thereafter. For orchards on dwarfing rootstocks in lighter soils and with inadequate irrigation, mulching may be more profitable. A thinner mulch layer coupled with other weed control strategies may provide an optimal system for tree performance and soil quality.

Using a Pollen Tube Growth Model to Improve Apple Bloom Thinning for Organic Production

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In apple (*Malus* x *domestica*) production, crop thinning during bloom produces the largest fruit, the greatest return bloom in the following year, and reduces biennial bearing. There are a limited number of fruit thinning chemicals approved for use under USDA organic standards, and many organic apple growers rely on a combination of liquid lime sulfur and fish oil applied during the bloom period. The application timing for this spray has been subjective, and is usually based upon the percent of full bloom that is open (e.g., an application at 20% and 80% full bloom). While this approach has become a standard practice in some growing regions, more precise application timing can be achieved through modeling the fertilization of the desired percent of king bloom needed to achieve a full crop at the desired

fruit size. When this target is achieved, a bloom thinner can be applied so that later blooming flowers are prevented from setting fruit. By measuring pollen tube growth rates under controlled atmospheric conditions using growth chambers, we have developed a model that calculates the time required to fertilize the king bloom after pollination. We have found that cultivar differences and temperatures affect pollen tube growth and the time required for fertilization, and can offer explanations for inconsistent bloom thinning results. The model is now being tested on a limited basis in commercial orchards with the goal to assemble specific modeling data for each commercially important apple cultivar. We believe that this model has the potential to improve crop load management when using liquid lime sulfur and fish oil for bloom thinning in organic apple orchards.

High Tunnel Production of Organic Raspberries: Effects of Fertilization Management

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High tunnel production under higher latitude growing conditions can enhance the economic sustainability of organic raspberry (*Rubus* sp.) fruit farming by extending the cropping season and improving fruit quality. However, only small areas are used for organic production even though the supply does not fulfill market demand for organic raspberries. The goals of this study were to compare two organic fertilization management methods (liquid and liquid+solid) with a conventional fertilization grown under high tunnels and to determine the effect of $CaCl_2$ foliar spray application on berry quality. A completely randomized experimental design with eight replicates was established at Les Fraises de l'Île d'Orléans, Québec, Canada and the combined six treatments were compared during 2010 and 2011. During the first growing season, no significant differences were observed in the soil nutrient solution collected from suction lysimeters installed at a depth of 15 cm, while soils that were organically farmed had higher concentrations of N (28%), P (23%), K (46%), Mg (93%), Ca (17%), Fe (10%), and Mn (17%) compared to conventionally fertilized soil, which resulted in higher leaf nutrient concentrations. At the end of the cropping season, 39-54% higher plant biomass, 21% higher yields, and 4% greater fruit size were observed under the organic production systems compared to the conventional system. Fruit quality was not affected by the $CaCl_2$ treatment. During the second growing season, similar results were observed, showing clear advantages for the organic farming system. Results will be discussed in term of alternative and sustainable growing systems for organic raspberries.

Horticulture – Abstracts Accepted but not Presented

Organic Cocoa Evaluation and Early Establishment in Northwest Guyana

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Preliminary results of morphological characterisation and evaluation of on-farm organically grown cocoa (*Theobroma cacao*) in northwest Guyana revealed a wide genetic diversity, the presence of fine flavoured cocoa, and the absence of symptoms of witches' broom disease (*Moniliopthora perniciosa*). Trinitario was identified as the most important of the genetic groups of on-farm cocoa sampled. Ten out of 65 accessions sampled were found to have good yield potential of combined bean weight ≥ 1.2g and pod index ≤ 21. While witches' broom disease was not observed on-farm in the northwest region of Guyana, it is reported in other parts of the country. When cocoa seedlings from selections with both high-yield and fine flavour characteristics were inoculated with the pathogen under controlled conditions at the Mon Repos research station in north-central Guyana, they showed susceptibility to Witches' broom disease. Organically grown cocoa plant selections were successfully established in field plots in association with the fast growing nitrogen fixing trees *Erythrina poeppigiana* and *Gliricidia sepium* used to provide shade to the cocoa. Cocoa seedling growth rate and above ground biomass from periodically pruned shade trees are reported. Northwest Guyana offers suitable growing conditions and a witches' broom disease free environment for survival of fine flavoured organic cocoa and leguminous trees provide organic fertility inputs for successful establishment of cocoa plants.

Non-chemical Approaches to Shelf life Extension of Sweet Cherries, a High Value Washington Crop

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Washington State is the largest U.S. producer of sweet cherries (*Prunus avium*) for fresh consumption, which contributes to its agricultural economy. However, the short shelf-life of sweet cherries limits industry efforts to meet strong market demand, especially the organic fresh fruit market. Presently, the greatest producer challenge is sustainably produced cherries with an extended market life considering the lack of approved postharvest treatments. As a supply-stabilizing tool, an extended market life would increase Washington industry returns by an estimated $60 million for each additional week that sound, high-quality fruit remain in the marketplace. The present study focuses on contributions of ethylene to cherry fruit growth, development, ripening and market life. Developing sweet cherries produce ethylene during and after anthesis and at early fruit drop, with no marked increase at maturity. Differences between cherry's ethylene pathway and that of other *Prunus* relatives, like peach, could underlie cherry fruit's non-climacteric nature. Identifying the biochemical step(s) and gene(s) responsible for this difference should help manage sweet cherry postharvest life and quality. Preliminary studies in respiration patterns, enzyme activities, and ethylene production during development of cherry provide possible explanations for divergent fruit drop patterns between 'Chelan', 'Bing', and 'Skeena'. An early peak in ethylene production in tiny fruitlets at color break decreased to undetectable levels upon maturation, suggesting ethylene production machinery to be functional until color break and then following a non-climacteric pattern. Identifying genes related to ripening provides opportunities for organic growers to have access to an expanded market, as breeding programs can more efficiently identify and select new cultivars with naturally longer shelf-lives and no need for postharvest chemical treatments. We are narrowing our understanding of genetic differences in ripening mechanisms among cherry varieties, in support of an organic production system that includes sustained genetic solutions to an extended cherry market.

Control of Fruit Cracking in Pomegranate

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Pomegranate *(Punica granatum*) belongs to the family Punicaceae and is native to Iran. India is the second largest producer of pomegranate, with an area of 113,000 hectares under cultivation and a total annual production of 792,000 metric tons. Until recently, 'Ganesh' was the most popular cultivar grown in India, with average yields of 25 t/ha. Because 'Ganesh' is susceptible to fruit cracking, a randomized complete block experiment was conducted to determine the effects of single, pre-harvest foliar sprays to

lime-sized fruits with boric acid (0.2% and 0.4% w/v), calcium chloride (0.5% and 1% w/v), and ferrous sulfate (0.5% and 1% w/v) to control fruit cracking. These materials are compliant with the US and other organic standards. A spray of 0.2% boric acid resulted in only 3.3% cracked fruits compared to 5.5% for the 1% calcium chloride spray and 28% for the untreated control. The boric acid spray did not affect mean fruit weight of undamaged fruit, however, each of the other treatments significantly reduced fruit weight. The 0.4% boric acid spray resulted in the highest yield of 34 kg/tree, followed by the calcium chloride spray at 32 kg/tree and the 20 kg/tree yield of the control. Among the sprays the boron content of cracked fruits was lowest in the 0.2% boric acid treatment (6ppm). The highest boron content (12.8 ppm) was observed in the 1% calcium chloride spray, followed by 11.7 ppm in the 0.5% calcium chloride, 11.1 ppm in the 0.5% ferrous sulfate and 10 ppm in 0.4% boric acid sprays. The boric acid treatments (0.2% and 0.4%) also resulted in higher concentrations (DW basis) of phosphorus (0.13 and 0.04%), manganese (0.90 and 0.13%), potassium (1.54 and 1.42%), calcium (1.11 and 0.61%), sulfur (0.04 and 0.09%), and zinc (8.67 and 17.00 ppm).

Plenary 2. Soil Management

Observations on the Biology of Organic Orchard Soils

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Two studies were used to evaluate the biology of organic orchard soils. The work focused on the three phases of organic systems: development, dynamic equilibrium and senescence. The first study consisted of a comparative analysis of the vertical distribution of nematodes, ciliates, flagellates and amoebae associated with four pairs of mature organic and conventional cherry orchards. One of the organic orchards was in an advanced state of decline. The second study investigated the dynamics of nematode community structure associated with transitioning a corn-soybean site into a certified organic apple orchard. Population densities of bacterial feeding nematodes, ciliates, flagellates and amoebae were significantly higher in the O-horizon in all eight cherry orchards, compared to the population densities at a 0-15 or 15-30 cm soil depth. The same was true for spores of endomycorrhizal fungi. The O-horizon of organic orchards had significantly higher population densities of bacterial feeding nematodes, ciliates, flagellates and amoebae than soil from the paired conventional orchards. In general, soil biological diversity was greater in the organic orchards than in the conventional orchards. During the apple orchard organic transition process, the relative population density of the Root-Lesion Nematode (*Pratylenchus penetrtans*) declined. The data indicate that the soil biology of the new organic apple orchard took seven years to reach a state of dynamic equilibrium. The dynamics of the soil biology of the new organic apple orchard were compared to the soil biology of an organic vegetable site that had been certified for 17 years and a neighboring conventional corn-soybean field with similar soil physical characteristics.

Soil Management in Organic Orchard Production Systems

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Central to organic production are soil management strategies designed to maintain soil fertility and increase soil biological activity and biodiversity by increasing soil organic matter content. Soil management was assessed in an organically managed high density 'Ambrosia' apple (*Malus* x *domestica*) orchard planted at 1m x 4m in April 2006. A randomized, replicated experiment was established to compare effects on soil properties and tree performance of four organically-acceptable soil management strategies: 1) annual compost application with regular mechanical tillage; 2) in-row application of alfalfa (*Medicago sativa*) mulch grown between the rows; 3) shredded bark mulch; and 4) black plastic mulch. The last two treatments received annual fertigation with fish fertilizer. Adequate tree vigor and leaf N concentration were maintained over the first six growing seasons for trees in all treatments despite high weed competition in the tillage and alfalfa mulch plots. The most vigorous trees by year 6 were in the bark mulch plots, which also had lowest leaf N and highest leaf and fruit P and K concentrations. There were no consistent effects on harvest yield or fruit quality. Soil samples collected at the end of the second, fourth and sixth growing seasons indicated rapid changes in soil physical, chemical and biological properties. Within two years, soil C and N were increased, mainly in the particulate organic matter fraction, in the tillage and alfalfa mulch plots relative to nearby conventional orchards. Tree root biomass to 30 cm depth was greater under bark and plastic mulches than under tillage and alfalfa treatments, and nematode indicators of soil food web structure were increased under bark mulch relative to other treatments. The implications of these soil management strategies for establishing organic apple orchards and maintaining soil quality are discussed in relation to patterns observed over the initial six growing seasons.

The Effects of Four Ground Cover Management Systems and Three Nutrient Sources on the Development and Performance of an Organic Apple Orchard in the Southern USA

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Organic apple (*Malus* x *domestica*) production in the Southern US has been limited by insufficient regionally specific research and demonstration. Producer surveys indicated information need areas were controlling competitive vegetation, and providing nutrition for organic systems. In 2006 the University of Arkansas established a replicated trial of 'Enterprise'/M.26 apple managed for organic certification to study the effects of groundcover management treatments: municipal green compost (GC), wood chips (WC), shredded paper (SP), and mow-blow (MB) and three organic nutrient source treatments: untreated control (NF), composted poultry litter (PL), and commercial pelletized fertilizer (CF) with the goal of developing recommendations for organic management in the region. The effects of treatments on tree growth and production, nutrient content, pest infestations and infections, soil physical and chemical properties, and soil biology were measured during establishment and early production phases of the orchard. Although ground cover management system affected tree growth and size in the first years, by the sixth growing season, there were no differences in tree trunk cross-sectional area, tree height, or canopy volume among treatments, although trees grown with WC had approximately 30% larger trunk cross-sectional area than those grown with SP or MB. There were no significant differences in tree size due to nutrient source. Although neither ground cover management system nor nutrient source affected total soil nutrient content, the use of GC ground covers and composted PL resulted in significantly higher available NO_3-N. After the first three cropping systems, trees treated with SP or MB had significantly lower cumulative yields. Nutrient source did not significantly affect cumulative yield. Control of plum curculio (*Conotrachelus nenuphar)*, San Jose scale (*Quadraspidiotus perniciosus)* and summer rots are still obstacles to fruit productivity and quality. Codling moth (*Cydia pomonella)* damage remained below 2% using foliar sprays of Bt, Cyd-X, spinosad, and Surround.

Concurrent Session 3A. Soils and Crop Nutrition

Effect of Four Different Soil Management Techniques on Apple Root Development

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Fruit yield and quality rely on a balance between above-ground photosynthetically active leaf surface and root activity. Soil management techniques play an important role in limiting competition with tree roots and improving soil structure, biodiversity and nutrient richness, aiming for optimal root growth and activity. In a high density apple (*Malus* x *domestica*) orchard, four different soil management techniques were applied both in the tree row and the drive alley: turfgrass (*Festuca* sp.); multi-species ground cover (*Festuca* sp*., Polygonum fagopyrum, Medicago sativa*); shallow tillage; and shallow tillage plus compost amendment. Influences on root growth, morphology and architecture were monitored from bloom to post harvest using 21 rhizotrone windows per treatment. Fruit yield and shoot growth were also recorded. Averaged across treatments, 60% of observed roots were localized between 0.1 to 0.3 m soil depth. Tillage effectively contained grass root growth and, together with the compost amendment, induced a shift of root allocation to deeper soil layers, increased average root diameter, and reduced root branching rate. Multi-species ground cover inhibited apple root growth during the first year of the experiment. The strongest inhibition was recorded during the two peaks of apple root growth in late spring and early autumn. The same periods were also characterized by the highest rate of ground cover root production. The turfgrass did not compromise apple root growth. Fruit size and yield were not affected by the treatments, but daily shoot growth was lowest in the presence of the multi-species ground cover. In the short term, the multi-species ground cover exerted strong competition and inhibited apple root growth. However, for the long term, the roots of mixed species may improve soil structure and increase organic matter content, thus enhancing soil quality. Therefore, results from additional years are needed to compare with these initial results.

Effect of Organic Fertilization on Soil Fertility, Tree Nutritional Status and Nutrient Removal of Mature Nectarine Trees

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Composted municipal solid waste is a good source of nutrients for fruit trees, but its timing of mineralization and nutrient release is difficult to predict. The objectives of the present experiment were to conduct a long-term (11 years) evaluation of the effect of organic fertilization on soil fertility, tree nutritional status and nutrient removal in a commercial nectarine orchard [*Prunus persica var. nectarina* 'Stark RedGold', grafted on GF677 peach x almond (*P. amygdalus*) hybrid]. The experiment was carried out near Ravenna, Italy with the following treatments: 1) unfertilized control; 2) mineral fertilization (P and K at planting, and split N applications; 3) cow manure [10 t dry weight (dw) ha^{-1} at planting; 5 t dw ha^{-1} yearly from the 4th year on]; 4) compost (10 t dw ha^{-1}at planting; 5 t dw ha^{-1} yearly from the 4th year on); 5) compost (5 t dw ha^{-1} $year^{-1}$), split application; and 6) compost (10 t dw ha^{-1} $year^{-1}$, split application). The compost was obtained from domestic organic wastes (50%) mixed with pruning material from urban ornamental trees (50%) after 3 months of aerobic stabilization. Available N, soil moisture and microbial biomass C were measured 4 times per year at two soil depths. Available N (mainly NO_3) soil concentration was increased by the high rate, early season application of compost only. Microbial biomass C was increased by the highest compost rate. Compared to the untreated control, cumulative (2004-2011) fruit yield was greater with compost application at 10 t dw ha^{-1} $year^{-1}$; fruit size increased with mineral and high rate compost fertilizations. Yearly application of compost at 10 t ha^{-1} promoted tree growth and fruit yield similar to mineral fertilization, while stimulating microbial biomass and not increasing the risk of nitrate leaching and pollution.

Fertility Management of Establishing Organic Black Currants

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While black currant (*Ribes nigrum*) production is prevalent in Europe and New Zealand, it has been slow to take off in North America. Availability of increasingly disease-resistant cultivars has sparked interest in organic currant production on Prince Edward Island (PEI) to satisfy a health-savvy Japanese market that prizes black currant berries for their high vitamin C, antioxidant levels and flavor. Organic production of this fruit is extremely limited globally, and the growing conditions in Atlantic Canada are starkly different from other countries. Two sites (1 and 2) of black currant 'Titania' were established on PEI in 2009 to measure the effects of nutrient rate and timing on the growth, yield and nutrient uptake of young plants. Seven fertility treatments were used based on kg ha^{-1} of estimated available N applied: control (SP0), three spring treatments (SP50, SP100 and SP150), one summer (SU150) and two treatments split across spring and summer (SL100/50 and SL50/100). The amendments were a mix of crab meal and poultry manure (Nutriwave™). Black plastic mulch was used to prevent weed growth. The two sites responded differently, with site 1 having almost twice the yield of site 2, and the treatments following very different patterns. In 2011, there was no difference in bush volume or yield among treatments at site 1 unlike site 2. Vegetative growth was highest for the SP150 at both sites, but the split treatments had higher yields. At site 2, vegetative growth rates of the summer-only and split treatments were much less than at site 1. Tissue N was significantly higher in amended treatments than the control at both sites. Tissue tests revealed that potassium and possibly phosphorus may be limiting at site 2. The best treatment for yield was SL100/50; SP50 and SU150 are not recommended, as growth of the plants was much lower.

Using Compost as Mulch for Highbush Blueberry

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In coastal British Columbia, Canada and adjacent areas of the Pacific Northwest, beds of highbush blueberry (*Vaccinium corymbosum*) are usually mulched with conifer sawdust (SD), which is very effective at deterring weed growth, moderating soil temperature and moisture, and maintaining pH in the range optimal for blueberry. However, the high C/N ratio of SD mulch can stimulate microbial immobilization of nitrogen (N), necessitating the application of fertilizers in excess of actual crop requirements to avoid crop N deficiency. Mulches of compost may not require supplemental N, but compatibility of compost mulch with blueberry production is not well known. In three field experiments, we compared SD to yard waste compost (YC) mulch with respect to effects on soil chemical properties, macronutrient dynamics, mycorrhizal colonization of roots, and crop response. In one of the three experiments, SD was compared to YC and bare soil but all three treatments were covered with woven polyethylene

weed mat for supplemental weed suppression. When applied as 10 cm thick mulch, YC reduced berry size and indicators of blueberry vegetative growth relative to SD. It also increased leaf N and K, but reduced leaf Mg to deficiency levels. Soil electrical conductivity increased in the first year after YC application to levels considered detrimental to blueberry root growth, but declined in subsequent years. Likewise, soil pH increased under YC compost relative to SD. YC also suppressed mycorrhizal colonization and diversity relative to SD. A combined application of 5 cm YC covered by 5 cm of SD increased leaf N relative to SD alone, but did not have detrimental effects on soil EC, leaf Mg or indicators of blueberry vigour. We conclude that compost should not be applied alone as mulch to blueberry, but it can be used effectively along with SD to mitigate the N-immobilizing tendency of SD mulch.

Effect of Some Organic Fertilizers on the Growth and Yield of Pomegranate in Iran

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Pomegranate (*Punica granatum*) is produced as an organic fruit in Iran. Natural fertilizers, especially animal manures, are commonly used. Since ancient times, the oil and seedmeal of eruca (*Eruca sativa*) seeds have been used as natural fertilizers for field and horticultural crops in some parts of Isfahan province (Najafabad City) in Iran. Because the eruca plants are grown as a rotational crop without any chemicals and pesticides, the products can be considered natural substances allowed for use on organic farms. To determine the efficacy of these materials on fruit yield and growth of pomegranate, a three year field experiment was conducted in an 8-year old planting of 'Malas'. Treatments included: 1) seed oil; 2) seedmeal; 3) cow manure; 4) cow manure + pomegranate leaves; 5) cow-sheep-chicken manure; and 6) control. For each treatment, 20 'Malas' trees were selected in a completely randomized design and studied for their vegetative growth and fruit yield. All treatments had significant differences compared to the control for most parameters. There was no difference between seed oil and seedmeal, and both were significantly different than other treatments. Highest fruit yield was obtained from eruca seed oil and seedmeal treatments. There were significant effects of year, likely due to different decomposition rates and impacts of the various amendments.

Effect of Subsoiling on Soil Physical Properties and Fruit Quality in Organic Conversion Kiwifruit

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Subsoiling is often practiced in Korean fruit orchards for the enhancement of soil aeration and drainage as well as the formation of fine roots. Surface soils in most Korean kiwifruit (*Actinidia chinensis* 'Haegeum') orchards are shallow (<30 cm depth), and compacted due to frequent machine traffic and bare soil conditions. Subsoil fracturing, using pressurized air injected at about 60 cm depth, was performed parallel to the vine row at 1.8 m distance from the vines during early spring to improve soil structure in a kiwifruit orchard in conversion to organic management. The orchard floor was fully covered with hairy vetch (V*icia villosa*). This subsoiling was done just after the application of organic compost (1.96% total nitrogen applied at 60 kg/vine) in order to facilitate its incorporation into the soil fractures by subsoiling. Soil resistance, measured with a soil penetrometer, was reduced 30 to 50% immediately after treatment and persisted 7 months later. Surface soil porosity increased by 25%. At harvest, kiwifruit vines with subsoiling produced larger fruit (86.5g) compared to the controls (81.1g). Fruits from the subsoiled vines also tended to have slightly higher soluble solids content and yields on average (not statistically significant). These results suggest that subsoiling can be useful for remediating poorly structured soils at the start of organic conversion, which can help maintain orchard productivity during this transition period from conventional to organic when yields often fall due to initial removal of agro-chemical sprays, plant growth regulators, and soluble fertilizers.

Soils - Poster Session

Apricot Root Development and Morphology as Influenced by Mulching and Multispecies Ground Cover

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In temperate environments characterized by a winter rainy season and a dry summer, roots of perennial fruit crops in a clay soil tend to concentrate in the shallowest layer and diminish exponentially with soil depth. The top 10 cm of the soil profile also have the highest concentration of grass roots. Soil management techniques influence interspecific root competition and can modify surface soil properties. In a field experiment in a five-year old apricot [*Prunus armeniaca*, grafted on *Prunus cerasifera* (Mir 29C)] orchard, two different soil management strategies widely used in organic farming were compared: multi-species ground cover, and organic mulching. Treatments were applied in the tree row where plant root growth was monitored through 21 rhizotron windows per treatment, over two years. Competition with multi-species ground cover decreased apricot root growth in the top 20 cm of the soil profile, while tree root development was enhanced by the multi-species cover at lower depths. Tree roots were also significantly thicker at lower soil depth with this management technique. Therefore the presence of the root of the other species induced an increase of the volume of soil explored by tree roots with more and thicker pioneer roots with explorative function. Tree root growth in the surface soil was generally reduced thus preventing roots from invading previously occupied niches. In the short term, organic mulch suppressed the growth of the ground cover and resulted in a reduction of interspecific competition and a lower tendency for the tree root system to migrate deeper in the soil. Finally, in all the treatments over two years, root growth was strongly influenced by plant phenology as well as by the weather, and the effect of the multi-species ground cover competition in the surface soil lessened with time, thus suggesting that over time the relative performance of the two treatments may shift due to changes in soil mechanical and biochemical characteristics.

Evaluating Orchard Floor Management Impacts on Soil Quality

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Organic stone-fruit production relies on maintaining or improving soil quality. Utah fruit growers often face poor soil quality associated with low soil organic matter and high pH. A transition organic peach (*Prunus persica*) orchard was established in 2008 at the Utah State Agricultural Experimental Station in Kaysville, Utah, USA to quantify the effect of tree-row and alleyway management on soil quality. Six combinations of tree-row and alleyway treatments were evaluated: living-mulch with legume alleyway (LL); living-mulch with grass alleyway (LG); non-living mulch with legume alleyway (NL); non-living mulch with grass alleyway (NG); tillage with grass alleyway (TG); and weed fabric with grass alleyway (WG). Tree-rows with a legume alleyway are mowed and blown monthly. Soils were sampled within the tree-row in June 2011 to a depth of 10 cm. Dehydrogenase activity (ug TPF g^{-1} soil hr^{-1}) in NL (7.36) and LL (6.69) treatments was non-significant from LG (5.84), but significantly higher than NG (4.08), TG (3.88) and WG (3.70). Microbial biomass (mg Cmic g^{-1} soil) in LL (35.6) and NL (32.8) was no different from LG (25.8), but significantly higher than NG (20.0), WG (19.5) and TG (19.2). The metabolic ratio of microbial carbon to mineralizable carbon (Cmic/Cmin) in NL (19.7) and LL (17.4) was not statistically different than LG (15.2), but was significantly higher than NG (9.82), WG (11.1) and TG (9.46). The ratio of basal respiration to microbial biomass (qCO_2) was significantly lower in LL (0.003) compared to NG (0.005), but not statistically different than TG (0.005), WG (0.004), LG (0.004), NL (0.004). Accelerated breakdown of residues blown in from the legume alleyway (LL and NL) may explain greater dehydrogenase activity, microbial biomass, Cmic/Cmin, and

lower qCO_2, indicating greater biological activity, substrate quality and substrate use efficiency among 'LL' and 'NL' treatments compared to 'NG' 'WG' and 'TG' treatments.

Ameliorating Effects of Some Basic Materials on Acidified Soil in Apple Orchards

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Some soil types are becoming acidified because of intensive fertilization and irrigation over the past 20 years of apple (*Malus* x *domestica*) production in Shandong Province, China. Soils prone to acidification usually contain less organic matter content and lower biological activity, which results in lower soil sustainable fertility index (SSFI), an index calculated comprehensively from soil nutrients, available nutrients and soil biological activity. Traditionally, lime and limestone are used to raise soil pH, but they are not so effective for improving soil fertility. We tested two alternative acidified soil amelioration materials (ASAM) for more comprehensive soil improvement. ASAM1 was made from plant ash, calcium cyanamide, calcium, magnesium and phosphorous, and ASAM2 from residues of soybean oil manufacture, used bentonite from soybean oil pigment absorption and the residues from Chinese spirit fermentation as an organic matter base. ASAM1, ASAM2 and lime were compared for improving acidified soil pH, bioactivity, SSFI and number of fungi, bacteria and actinomycetes in two apple orchards where soil pH was ~5.5. Both ASAMs applied in this study led to significant improvement in the indices investigated. ASAM1 application increased SFSI by 87% and 191%, and pH by 0.50 and 0.46 in the two orchards, respectively, in comparison with the control. However, for lime application there was no significant increase in nutrient elements, soil enzyme content and SSFI. The results suggest that some new mixtures of soil amendments made from basic materials and agricultural by-products and wastes can be used for more comprehensive improvement of acidified soil in old apple orchards.

The Effect of Different Organic Fertilizers and Soil Conditioners on the Soil Microbial Populations in Organically Managed Strawberry Plants

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The management of fertilization under organic farming affects the interaction between soil microorganisms and the plants. Beneficial soil nematodes are usually more abundant in crop management systems with sophisticated crop sequences and organic amendments. However, the impact of non-plant-parasitic and bacterial-feeding nematodes on plant growth-promoting bacteria and on horticultural plants is not well understood, particularly regarding the effects of application of organic inputs and microbial inocula as soil amendments. A field study was conducted on organically grown strawberries (*Fragaria* x *ananassa* 'Elsanta') to monitor the structure of nematode communities and evaluate the soil microbial populations in response to five different organic fertilizer and amendment treatments: 1) seaweed extract; 2) vermicompost extract; 3) stillage from yeast production; 4) a microbial consortium composed of mycorrhizal fungi and plant growth-promoting rhizobacteria; 5) control. Treatments were applied to the soil and/or plants. Control plants did not receive any treatment or were fertilized with dry manure. The products generally induced an increase in the total population of nematodes by increasing the bacterial and fungal feeding species and decreasing the plant parasitic species. Bacterial and fungal rhizosphere populations were both increased by the treatments. Some products influenced the microbial community even when applied as a foliar spray, suggesting an effect through the exudates the plant releases into the rhizosphere. As the various organic amendments and fertilizers applied affected the biological quality of the soil in a relatively short time, long term effects of these products can be expected on the biological soil quality and thus on plant growth and health.

Direct Seeding Legumes into Orchard Alleys for Nitrogen Production

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The orchard drive alley is an under-utilized portion of many orchard ecosystems. By planting leguminous species in this area, it is possible to produce a significant portion of the nitrogen needs of the orchard for a lower cost than other organic nitrogen sources by mowing the vegetation and blowing it onto the tree row where it mineralizes and releases available N over the tree roots. Four perennial legume species (alfalfa *Medicago sativa*, Ladino white clover *Trifolium repens*, birdsfoot trefoil *Lotus corniculatus*, kura clover *Trifolium ambiguum*) were compared with the resident grass cover crop. All legumes were direct-seeded into the alley to avoid any soil disturbance. The legume species performed differently over time. Ladino clover established quickly but faded by Year 3. Alfalfa established well in Year 1 and increased biomass each subsequent year. Trefoil and Kura clover were slowest to establish, and improved stand each year. Alfalfa was able to contribute approximately 50 kg total N/ha with four mowings over the season, and a C:N of 10. Screening these legumes for characteristics specific to orchards (e.g., shade tolerance, tolerance of tractor traffic) is needed to optimize their use.

Composted Poultry Manure as a Potential Nutrient Source for Organic Tree Fruits

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Nutrient sources for organic orchard production are limited in the Annapolis Valley of Nova Scotia, Canada. Composted and fresh poultry manure are available; however they have not yet gone through the certification process needed to allow their use in organic tree fruit production. Once these materials are certified, there is concern that fall-applied poultry manure-based nutrients could reduce tree hardiness and yield potential. This two-year study on mature 'McIntosh' apple (*Malus* x *domestica*) trees included fall-applied fresh or composted poultry manutre at rates containing 34, 67, 101, 135 and 168 kg ha^{-1} actual N, and a control treatment of spring-applied ammonium nitrate (34 kg ha^{-1} actual N). No reduction in hardiness or yield was found. More work is needed to verify movement of nutrients over the winter to understand potential environmental impacts. If nutrient movement is not a problem, application prior to soil freezing may offer a solution to the area's large supply of manure and provide a local source for a wide range of macro and micro nutrients.

Orchard Floor Management Affecting the Performance of Young Organic 'Honeycrisp' Apple Trees

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Six orchard floor management systems (OMSs) were installed in 2010 in a young 'Honeycrisp' apple (*Malus* x *domestica*) orchard (planted 2008) aiming to suppress weed growth. Treatments were: bare ground used as control, reflective mulch, reflective mulch placed over composted manure,

composted manure, green manure and bent grass as companion plant cover, and were set out in replicated, randomized plots. The OMS affected weed abundance, tree growth, leaf photosynthesis and fruit production in 2011. Reflective mulch and bent grass were effective in weed suppression. Compost and green manure plots had a high percentage of weed cover, although weed composition between these two OSMs were different. Trunk cross sectional area (TCA) was highest in trees treated with compost (25 cm^2), followed by trees growing in the reflected mulch and bare ground plots (13 cm^2); bent grass and green manure plots had the slowest growing trees with a TCA of 10 cm^2. Leaf photosynthetic rate was highest in trees treated with compost. This is the first cropping season for this 3-year old orchard. Although trees have not yet reached their full cropping potentials, those in compost plots and reflective mulch plots yielded on average 31 and 12 fruits respectively. Placing reflective mulch over compost had enhanced fruit yield with an average of 45 fruits produced per tree. Trees in bare ground, bent grass and green manure plots produced few fruits (0 – 4).

Concurrent Session 3B. Organic Fruit Systems

Organic Blueberries in South Chile: Challenges for Growers

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In Chile, about 11.5% of the actual 12,900 hectares cultivated with "highbush" and "rabbiteye" blueberries (*Vaccinium* sp.) are certified organic, with interest in organic production mainly in the cooler and rainy southern part of the country (equivalent to Oregon and Washington State, USA). Control of perennial and annual weeds (e.g. *Convolvulus arvensis*) in an ecological way is by far the greatest challenge due to lack of and increasing cost of labor, and difficulties in sourcing pinebark, straw or sawdust to mulch the planting row. Therefore synthetic soil covers are preferred. Fruit disease caused by *Botrytis cinerea* is the main problem both pre- and post-harvest. Native insects can destroy full grown blueberry plantations, especially weevils of the family *Curculionidae (*e.g. *Aegorhinus superciliosus, A. nodipennis, Naupactus leucoloma, N.xantographus, Otiorhynchus rugosostriatus* and *O. sulcatus)*, and of the family *Scarabeidae (*e.g. *Hylamorpha elegans* and *H. cylindrica*), among many others. The "trumao" soils of the area of volcanic origin are suitable for blueberry production given their favorable bulk density, high level of organic matter and low pH. The primary challenges for growers are the lack of appropriate machines for mechanical weed control and harvest, together with highly variable prices each season for fresh organic blueberries.

Organic Rabbiteye Blueberries in the Southern Coastal Plain

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The Southern Coastal Plain is the most challenging region in the United States to successfully grow fruit and nut crops organically. Abundant rainfall, and high temperatures and humidity during the growing season promote intense weed, insect and disease pressures. Rabbiteye blueberry (*Vaccinium virgatum*), native to this region, is a promising fruit crop for commercial organic production here due to its innate ability to resist insect pests and diseases. Weed control (grasses and broadleaf weeds) is especially problematic for up to 9 months a year. The use of mulches reduces the incidence of weed competition, increases organic matter and helps buffer and reduce soil pH. Two multi-year studies tested potential best management practices for organic culture of 'Brightwell' blueberries in southern Georgia, and compared yield, berry weight and soluble solids with conventional production. Mulches and a rolling cultivator were more effective than organic burn down herbicides in controlling weeds. Hand-weeding was still needed at the interface between mulches and between-row grass strips. Pine straw and pine bark mulch resulted in the lowest hand weeding times. Pine bark mulch was the highest yielding treatment. The establishment of organic blueberries was also good with some plant- or synthetically-derived mulches, and mulch choice can largely be based on availability and price. In a separate 6 year study with pine bark mulch and conventional culture, net income per hectare was higher for organically-grown compared to conventionally-grown blueberries based on a 50% price premium for organic blueberries. Key insect pests encountered were blueberry gall midge (*Dasineura oxycoccana*) and leaf beetle (*Colaspis pseudofavosa*), although neither were economically damaging in our studies. Leaf spot (*Septoria albopunctata*) was the greatest disease problem detected, and was effectively controlled with the foliar application of organic fish by-products. Although mummy berry (*Monilinia vaccinii-corymbosi*) can be a problem in the culture of rabbiteye blueberries, it was not in our studies

Developing Organic Stone-Fruit Production Options for Utah and the Intermountain West

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Fruit production in Utah and throughout the US Intermountain West has come under increasing pressure due to rising input costs, diminishing water supplies, loss of export markets, and urban encroachment. These very challenges, however, also present considerable opportunity in the form of increased local and value-added marketing potential. Organic production may help growers gain access to new markets and cut production costs through enhanced synergies between ecosystem services and production goals. A peach (*Prunus persica*) orchard was established in 2008 with six organic treatment combinations: 1) straw mulch + high rate compost (90 kg N) + grass alleyway; 2) straw mulch + reduced compost (45 kg N) + legume alleyway; 3) living mulch (low-growing shallow rooted sweet alyssum, *Lobularia maritima*) + high compost + grass alleyway; 4) living mulch + reduced compost + legume alleyway; 5) woven plastic mulch over reduced compost + legume alleyway; 6) tillage + high compost +grass alleyway. Separate trials evaluated novel cover crops for potential integration in orchards with shallow alkaline soils, arid climates, and cold winters. Tree growth was initially slowed in combination with both living and non-living mulches; however, by the end of 2011 trees were largest in legume alleyway treatments despite considerable tree row weed pressure. Soil quality and arthropod diversity were also enhanced in legume alleyway treatment combinations. Legumes grown in orchard alleyways contribute up to 143 kg/ha total N. Fertilizer savings and reduced competition of trees with weeds are offset by increased water use by legumes. The ultimate goal of the research is to quantify the benefits and/or tradeoffs between different organic management scenarios on water use, pest dynamics, and fruit and soil quality in order to assist growers in making both economically and environmentally sound organic management practice decisions.

Organic Fruit Farming as a Prototype of Reconciling Performances?

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Organic fruit farming (OFF) appears to combine multiple benefits: by using fewer pesticides, OFF may degrade biological resources less than other forms of farming, which suggests OFF as a model for ecological practices. Also, organic fruits are attracting more and more consumers who are willing to support OFF through higher prices that could improve farm profitability. Despite these two positive assessments, the lower yields and higher production costs generally associated with OFF challenge consideration of OFF as a "prototype" of sustainable farming. What are OFF performances exactly? Similar to a study of apple (*Malus* x *domestica*) sustainability in Washington State, USA, we analyze the global durability of OFF by examining the agronomic, environmental, economic and social

performance of organic fruit systems in southeast France. We summarize the results of our studies from 2004 to 2010, combining 1) measurements from experimental peach (*Prunus* x *persica)* plots in OFF; 2) observations in peach orchards in OFF and in integrated production; and 3) farm surveys in OFF, conversion and integrated farming for apple, peach, and pear *(Pyrus* x *communis).* Our results acknowledge the great diversity of practices and strategies among the organic farmers. The best environmental profile of OFF was confirmed by using an indicator that integrates impacts on biodiversity, quality of water, and operator's health. Yield reductions can be as high as 20% in experimental orchards and 50% in producers' orchards, but these results are for varieties poorly adapted to OFF. We also found that even with lower yields, and more work, the incomes for farms in OFF are similar to those in integrated production, and sometimes even greater, due to better prices for farmers. Maintaining higher prices to farmers in a rapidly growing organic sector is probably crucial for insuring farm economic viability.

Prospects and Challenges of Organic Fruit Production in Pakistan

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Pakistan has an agro-based economy with about 70% of the population engaged in this enterprise. Geographically, Pakistan is blessed with a diverse climate which is quite suitable for the production of more than fifty types of fruit throughout the year. A range of temperate, subtropical and tropical fruits are being produced in all five provinces. Citrus, mango, guava, dates, banana, apple, peach, apricot, plum and grapes are leading fruit crops. Among them citrus, mangos, dates and apples are exported. Although the export of some fruit commodities such as 'Sindheri' and 'Chunsa' mangos, and 'Kinnow' mandarin have tremendous demand in the international markets, their export market share is less than other exporting countries. This paper discusses the prospects and challenges in the development of organic fruit growing in the Asian region, with special focus on Pakistan. At present China, Japan, India, Indonesia, Sri Lanka and Thailand are the leading organic fruit producing countries. Japan has emerged as the third largest market for organic fruit followed by Europe and the USA. Consumer demand for organically produced fruit is increasing due to increased awareness about health and environmental implications of growing fruit using conventional methods. However, small land holdings, lower yields, widely dispersed farms, long term investment, low in-hand capital, and lack of national policy for organic fruit farming discourage growers to shift from conventional fruit growing to organic fruit production. There is lack of awareness of organic fruit production in Pakistan and a great need to establish an organic certification organization at the national level in collaboration with global organic organizations. Formulation and implementation of organic legislation, regulations, and standards for organic production, as exist in other Asian countries, will help to increase the growth of the organic fruit production sector in Pakistan.

Systems - Poster Session

Integrated Rotation Systems for Soil Borne Disease, Weed and Fertility Management in Strawberry/Vegetable Production

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Continued growth of organic strawberry (*Fragaria* sp.) and vegetable production in coastal California faces major challenges. Soil-borne disease management without the use of chemical fumigants especially for Verticillium wilt (*Verticillium dahliae),* efficient nutrient management to prevent spring and fall leaching losses, and high costs for weeding are especially challenging areas. In conventional systems, due to stringent regulations and air quality concerns, the sustainability of chemical fumigant dependent systems is uncertain. Verticillium wilt is hard to manage given its wide range of host crops, long-lived propagules, and high sensitivity of strawberry to the disease. Among crops grown in this area, only broccoli, celery, and alliums are non-hosts, whereas lettuce, artichoke, tomato, potato, pepper, cucurbits, cauliflower, cabbage and spinach are hosts. This makes it difficult for diversified organic farms to devise crop rotations that include strawberries and avoid Verticillium hosts. A team of researchers, growers, farm advisors, and NGOs are tackling these issues by testing combinations of three non-chemical approaches: anaerobic soil disinfestation (ASD, an ecological alternative to methyl bromide fumigation); broccoli (*Brassica oleracea*) residue incorporation; and mustard (*Brassica* or *Sinapsis* sp.) cake application. Using fields highly infested with *V. dahliae*, we initiated replicated split-plot experiments with 3-year rotations: 1) broccoli-strawberries-lettuce (*Lactuca sativa*), 2) cauliflower-strawberries-lettuce, and 3) fallow-strawberries-lettuce as main plots at one organic and one conventional farm in June 2011. Split plot treatments (ASD, mustard cake, ASD plus mustard cake, and untreated control) were applied prior to strawberry planting in Nov. 2011. An additional fumigant control split plot treatment, (PicChlor 60) was used in the conventional site. *V. dahliae* populations in soil, weed density, degree of wilt symptoms, soil-plant N dynamics, and crop yields will be monitored and net returns will be evaluated. Data on N dynamics and changes in viable *V. dahliae* population in soils during the first year are discussed.

Field Testing Tools for Organic Blueberry and Cranberry Production in British Columbia: Disease, Insect and Nutrient Management

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Blueberry (*Vaccinium corymbosum*) and cranberry (*Vaccinium macrocarpon*) production in British Columbia is concentrated in the Fraser Valley. The majority of berries are produced conventionally, however many producers would like to transition some of their acreage to organic production. Limitations for organic production include lack of registered products or experience using tools that are suitable for organic production - particularly for pest control and nutrient management. Over the past five years we have been conducting on-farm trials to evaluate tools for organic blueberry and cranberry production. For blueberries we have evaluated biofungicides for mummyberry (*Monilinia vaccinii-corymbosi*) control and municipal composts as a replacement for chemical fertilizers. In cranberries our studies have focused on using entomopathogenic fungi (e.g., *Metarhizium anisopliae*) for management of root feeding insects and acetic acid for weed control. Commercial formulations of *Bacillus subtilis* were effective for management of mummyberry in blueberries. Fertilizing with municipal composts combined with chicken manure resulted in levels of blueberry yield and lateral growth equal to chemical fertilizer. Commercial formulations of *M. anisopliae* did not result in increased mortality of either cranberry girdler (*Chrysoteuchia topiaria*) or black vine weevil (*Otiorhynchus sulcatus*) larvae in field trials. As both pests are susceptible to *M. anisopliae* in bioassays, the issue appears to be delivery of spores through the duff layer to the root zone of cranberry vines. Finally, weekly applications of acetic acid (4% solution) were effective for the control of most perennial weeds, except horsetail *(Equisetum arvense).*

High Tunnels Facilitate Niche Market Organic Sweet Cherry Production Potential in the Great Lakes Region

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Seven years of research on the adaptation of multi-bay high tunnels for growing sweet cherries (*Prunus avium*) has identified some significant advantages for organic production, which otherwise is problematic in the humid, rainy, continental climate of the Great Lakes region of the U.S. The additional production costs associated with high tunnels are somewhat offset by the improved protection from rain-induced fruit cracking and the reduction in certain pest pressures, but growers should target high value niche markets, such as pick-your-own operations, farm markets, farmers markets, community-supported agriculture (CSA) operations, restaurants, or specialty organic or local-foods retailers. Specialized strategies to adapt sweet cherry production to the modified climate and limited space under tunnels include the use of dwarfing rootstocks, the adoption of high density training systems to achieve narrow canopies for optimized light and labor efficiency, and the use of bumblebees (*Bombus terrestris* or *B. impatiens*) for pollination since honeybees (*Apis mellifera*) often become disoriented under tunnel covers. The omission of rain during the growing season not only reduces the potential for fruit cracking, but also eliminates cherry leaf spot (*Blumeriella jaapii*), a serious foliar disease in the Great Lakes region. Bacterial canker (*Pseudomonas syringae*) can be reduced, though not eliminated, and brown rot (*Monolinia fructicola*) remains a serious problem for organic producers. The incidence of powdery mildew (*Podosphaera clandestina*) is increased under tunnels, but genetically-resistant cherry cultivars hold promise for control. Predation by Japanese beetles (*Popillia japonica*) is significantly decreased under tunnels, but numerous insect pests are not affected, including cherry fruit fly (*Rhagoletis cingulata*), plum curculio (*Conotrachelus nenuphar*), spotted wing drosophila (*Drosophila suzukii*), black cherry aphid (*Myzus cerasi*), oblique-banded leafroller (*Choristoneura roseceana*), and spider mites (*Tetranychus urticae*). Other specialized management strategies, such as tunnel management for earlier ripening, organic weed control, and frost protection will be discussed.

High Tunnels for Organic Raspberry Production in the Midwest U.S.

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Demand for local and organic foods in the Midwest United States has increased opportunities for sales of fresh produce, which can be marketed directly to consumers or through local retailers for higher prices. Organic berry production is scarce in the Midwestern US because of pest and disease pressures, making western states the primary supplier of fresh organic fruits like raspberries (*Rubus idaeus*). High tunnels, however, can prevent several important diseases and increase opportunities for organic pest control. Fruit quality also is improved and yields often are twice that of open field production. Therefore, high tunnels are a promising technology for increasing organic raspberry production in the Midwest, but strategies for soil health, nutrient, and insect management are still being developed. With multi-bay or three-season tunnels, the plastic is removed seasonally to prevent damage from snow. Consequently, the soil is exposed to precipitation, which can remove excess salts and create opportunities to incorporate soil amendments. Raspberries have a consistent nitrogen requirement throughout the growing season that can be difficult to supply organically under dry environmental conditions and drip irrigation. Initial observations suggest that compost and solid organic fertilizer are effective if tilled into the row prior to planting, but are less effective if broadcast over established rows during spring, prior to covering the tunnels. In addition, a number of insect pests have been observed that pose a moderate threat, but so far have been managed with organic control strategies. Currently, control of spotted wing drosophila (*Drosophila suzukii*) is the greatest concern due to a scarcity of organic pesticide alternatives and the potential for organic pesticide resistance.

Systems – Abstracts Accepted but not Presented

Organic Fruit Culture in Iran: Future Prospects and Challenges

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Iran is one of the main production regions for fruit crops in the world. Different fruits and nuts, such as date, walnut, pistachio, fig, grape, stone fruits, apple and citrus fruits, have been under cultivation in the country for millennia. In addition, orchards in Iran are mainly maintained using traditional management which involves avoiding the use of chemicals. Currently, around 300,000 hectares of arable lands are under organic fruit production which includes IPM, HACCP and GAP systems. This provides a unique potential for developing a well organized system for organic fruit production. Owing to the fact that rural communities are the most benefited segment of Iranian society, focusing on organic fruit culture will have genuine impacts for sustainable development in rural areas. The main challenge facing organic fruit producers in Iran is the lack of a national system for organic certification of horticultural crops, particularly for fruits and nuts. Currently, up to 5% of Iran's fruit production is categorized as organic, but this is not nearly enough for sustainable production. We are currently focusing on increasing the arable land in organic cultivation and also on documenting a national agreement for Good Storage Practice (GSP) in fruit crops. In this paper we describe the prospects and challenges for organic fruit production in Iran.

Field Production Techniques for Organic Pineapple Production in Guyana

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Pineapple (*Ananas comosus*) grows best in full sun rather than under shade. The role of trees in organic pineapple production is more for the organic inputs they provide for plant nutrition than for shade. In Mainstay/Whyaka, Guyana, where organic pineapple is cultivated in commercial quantities, land preparation follows the traditional slash and burn method. Native forest trees are clear-felled and burned and the ash serves as a source of fertilizer for the sequential pineapple crop. Fast growing nitrogen fixing trees such as *Acacia* sp. are planted during the pineapple crop to enrich the returning fallow vegetation. Typically, pineapples are grown from a single plant crop for three years, over which three harvests are made. The fields are then abandoned and allowed to bush fallow for up to 15 years before re-conversion of the secondary forest to agriculture. Trees from re-growing stumps that form the secondary vegetation and trees from introduced, improved fallow species, provide a valuable service in carbon sequestration, watershed protection and ecological regulation including niche refugia for useful insects, and pollination services. Land clearing methods, improving the fallow vegetation, and use of organic inputs for pineapple plant nutrition and insect control are described for smallholder operations in Mainstay/Whyaka, Guyana.

Concurrent Session 4A. Research Funding Panel

A discussion of the prospects and strategies for funding organic fruit research into the future by Deirdre Birmingham (Organic Farming Research Foundation), Franco Weibel (FiBL), Jim McFerson (Washington Tree Fruit Research Commission), and Chuck Benbrook (formerly The Organic Center).

Concurrent Session 4B. Economics

Global Expansion of Organic Fruit Area

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The organic food market continued to grow in the past several years despite global economic stresses, but at a slower rate than in the past. Europe and North America were still the dominant global markets, accounting for some 95% of sales. Growth increased in 2010 in the USA, with fresh fruit and vegetable sales expanding by about 12%. Global data from 2010 will be compiled to estimate the area of organic fruit production and compare it to previous estimates from 2008 and 2006. Leading fruits have been grapes and tropical and subtropical fruits, accounting for 30% and 28% of all organic fruit area globally in 2008. In that year, approximately 75% of all the organic fruit production area was in Europe, with grapes as the leading crop. Over 5% of all grape hectares in Italy were certified organic or in conversion, and organic grapes accounted for 2% of all grape hectares worldwide (grapes have the largest production area of any fruit crop in the world). The paper will present the most recent information on production area trends for organic fruits.

Organic versus Conventional Fruit Production Systems in California: Resource Use and Associated Costs

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It is commonly believed that organic production is more labor intensive than conventional production and that organic production does not make use of pesticides. In fact, relative labor intensity varies significantly by crop and organic production makes important use of pesticides allowed by the National Organic Program. Allowed pesticides are not precluded from use in conventional production, however. The comparison of pesticide use varies by crop. This paper compares the farming practices used for organic and conventional fruit crops in California with respect to inputs employed (materials, fuel, and labor) and the related costs. For each crop, the differences and similarities in production methods and the related costs for fertility, pest control, disease control, and management of fruit load are detailed. Resource use is compared in terms of gallons of fuel, hours of tractor operator and other labor, and equipment investment. A model of hypothetical commercial organic and conventional farms in California is developed for both organic and conventional production of raisin grapes in the San Joaquin Valley and pears in the Sacramento Valley. The results show that fertility and weed control costs are higher for organic production, pest control costs are lower for raisins and higher for pears, and disease control is comparable to conventional production. Labor is comparable between the systems for raisins but higher for pears due to the use of mating disruption and hand hoeing. The circumstances under which cultural practices are insufficient for pest control and allowed pesticides are employed in organic systems are identified as well as fertility management practices. A ranging analysis will be included to show the breakeven yields and prices for the two systems. The study illuminates the complexity of organic production and the unique challenges faced by different fruit crops.

Economic Analysis of Five Apple Cultivars in a Top-Grafted Organic Orchard, 2006-2011

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Growers who transition to organic apple (*Malus* x *domestica*) production often question what their most profitable action may be. One action is to change the cultivars in an orchard by completely replanting the site or top-grafting existing trees. Advantages of top-grafting over planting new trees on the same site include: reduced labor and equipment required for tree removal and land preparation; minimized loss of production time by not requiring a fallow period to manage replant disease; and reduction in establishment costs compared to purchasing nursery stock and trellis materials. Another stated advantage of top-grafting is that the orchard may produce a full crop sooner than a newly established orchard, thus increasing short-term cash flow. Orchard profitability was evaluated on five apple cultivars in a certified organic orchard at the University of Vermont Horticultural Research Center in South Burlington, VT: 'Ginger Gold', 'Honeycrisp', 'Liberty', 'Macoun', and 'Zestar!'. The orchard was originally planted in 1988 with the cultivars 'Liberty' and 'McIntosh' on M.26 rootstock; in 2006, the orchard was top-grafted to the five new cultivars. The cultivar experiment uses a Randomized Complete Block design with a total of eight two-tree replicates of each cultivar in block 1, and 11 replicates in block 2. The blocks relate to the original cultivar (i.e., 'Liberty' or 'McIntosh') which is now the interstem of each tree. Actual management costs including labor, equipment, and input costs were recorded as were tree survivability, crop yield, fruit quality, and commercial grades for fruit assessed over the study period. Orchard profitability was analyzed from 2006-2011 for each cultivar. Long-term financial risk was assessed by computing the net present value (NPV) for each cultivar and interstem combination in the planting. For both interstems, 'Ginger Gold' had the greatest net present value over the course of the study. Total crop yield and tree survival rate were primary determinants of profitability for all cultivars.

An In-Store Assessment of Consumers' Willingness-To-Pay for Organic Apples: Does Size Matter?

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Organic food sales in the U.S. have grown about 20% annually, from $3.6 to over $21 billion, between 1997 and 2008. The demand for organic food exceeds supply despite increases in U.S. and Washington State certified acreage and increases in imports of organic food. Premium prices for organic foods exist at the farm gate and retail levels. Larger organic producers are filling market demands, accounting for a growing share of total organic sales (84% of total market by 2006). Consumers have demonstrated willingness-to-pay (WTP) a premium for organic fruits, but high premiums may deter additional market growth. Willingness-to-pay data collected solely by questionnaire is typically biased upward as there is no incentive for consumers to reveal their true preferences. This study assesses consumers' WTP for two distinct sizes of certified organic (labeled) Washington Extra Fancy grade 'Fuji' apples (*Malus* x *domestica*) using an auction mechanism at the point of purchase. The experiment consisted of two rounds of bidding, and completion of a paper questionnaire to obtain information on beliefs and attitudes. Our results indicate that individuals in our sample were less willing to purchase organic over conventional apples; however, consumers who were willing to purchase organic fruit were willing to pay significant premiums. Although the size of apples did not significantly impact willingness to purchase apples, larger apples received a premium. The premium associated with organic was constant across different apple sizes. We also found that, although demographics impacted

the level of WTP, organic premiums were constant across sample demographics.

Plenary 3. Organic Fruit: Impacts and Progress

Impacts of Organic Production Systems on Fruit Nutritional Quality and Safety

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Mounting evidence confirms that how and where fruit is grown has significant impacts on both nutrient density and food safety. The sources and levels of nitrogen, in particular, play a key role in governing physiological growth patterns, which in turn drive nutrient levels. New tools and metrics are available to quantify the nutritional quality and pesticide-related food safety benefits of organic systems, and will be used to provide an overview of the value proposition for Pacific Northwest U.S. (PNW) organic fruit production. In addition, data will be presented on the dramatic improvement since passage of the Food Quality Protection Act in the pesticide risk levels in several major conventional PNW tree fruit crops, although worrisome trends in pesticide risk in imported fresh and processed fruit products also warrants greater attention (e.g., carbendazim in orange juice concentrate). Unique challenges associated with arsenic residues in tree fruits and juices will also be discussed. Emerging metrics and sustainability standards will be summarized and possible implications for consumer confidence in, and demand for, PNW fruits and vegetables will be analyzed.

Nutritional and Organoleptic Characterization of Apple Produced by Organic and Integrated Production Systems in Lleida (Spain)

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'Golden Smoothee' and 'Fuji' apples (*Malus* x *domestica*) were grown according to organic (OP) and integrated production (IP) systems, under similar soil and climate conditions in Lleida (Spain). Fruit quality parameters [ethylene production, starch index, weight, diameter, color, firmness, titratable acidity (TA), soluble solids (SSC), phenols and ascorbic acid (AA) content] were measured in addition to the level of physiological disorders and sensory measurements, both at harvest and after 76 and 159 days (for 'Golden Smoothee') or 153 days (for 'Fuji') under cold storage at 0.5 $\pm$ 0.5 ºC. Analyses were carried out after removal from cold storage and after 7 days at 20°C. The macro and micronutrient contents were also determined at harvest. No significant differences in ethylene production were found between OP and IP systems for either cultivar at harvest, whereas OP 'Golden Smoothee' showed higher rates of starch index than those apples produced by IP. 'Golden Smoothee' fruits did not show significant differences in the content of N, P, K, Mg, B, Fe, and Zn between either production system. However, the Ca and Cu contents were greater in OP fruits. In 'Fuji' apples, N, P, Ca, and Zn were not significantly different, but K, Mg, B and Cu values were higher in OP than in IP fruits. The sensory measurements showed that 'Fuji' was much more accepted by consumers than 'Golden Smoothee' apples regardless of the storage period and the production system. 'Fuji' apples at harvest (in both production systems) and at 76 days after removal from cold storage (OP system only) were correlated with acceptability. The acceptability was positively associated with a higher soluble solids content and a greater perception of sweetness and juiciness. Titratable acidity and sourness were inversely correlated to acceptability. Few differences in physiological disorders were detected.

Linking Soil Health to the Nutritional Quality of Fruit

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Decades ago it was argued that soil-building practices, a current requirement for organic certification, improved crop quality. Recent evidence suggests that organic farming practices that enhance soil microbial activity improve certain aspects of fruit quality, such as phytochemical concentrations and antioxidant activity. In studies of apples (*Malus* x *domestica*), strawberries (*Fragaria* x *ananassa*), and tomatoes (*Solanum lycopersicum*), we found that there is a positive link between soil fertility management and these fruit quality parameters. Organic, conventional, and integrated apple production systems were compared over a 10-year period on a commercial orchard in Washington State. Matched pairs (for proximity, cultivar, soil type, and topography) of commercial organic and conventional strawberry fields in coastal California were compared for two years. Tomato plants were grown in a greenhouse in either organic or conventional soil media and fertilized with either liquid organic fertilizer or a soluble, ionic nutrient solution. In one experiment, plants were either exposed to herbivory by green peach aphids (*Myzus persicae*) or not. Tomatoes grown using organic soil fertility management had higher concentrations of phytochemicals and antioxidant activity, and their leaves had higher concentrations of several mineral elements than conventionally grown plants. Organic soil fertility management may also improve overall crop health by reducing herbivory by green peach aphids. The genetic implications of these responses will be discussed.

Biological Control of Postharvest Diseases: Hurdles, Successes and Prospects

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The acceleration of research on biological control of postharvest diseases (BCPD) has resulted in the development of a few commercial products for controlling postharvest decays of temperate and subtropical fruits. The demand for alternatives to synthetic fungicides is much greater than the supply available through new technologies, including biological control. Research worldwide has solidified the usefulness of BCPD while also identifying its limitations. These limitations result from knowledge gaps that can be addressed by additional research and regulations that are poorly adapted to microbial biocontrol agents. The research gaps include limited understanding of the mechanisms of biocontrol on fruit, microbial ecology of fruit surfaces, survival of antagonists under adverse conditions, and improvement of antagonists by changing their physiology and environment to prolong their shelf life and increase their efficacy. More research is also needed to determine compatibility of biocontrol with other alternative treatments, to adapt biocontrol to new production technologies such as mechanical harvesting that may predispose fruit to decay, and to expand the use of biocontrol products to new commodities and different diseases. Currently available products were developed to control decays originating from wound infections, however, significant postharvest losses on various fruits may also occur from decays originating from latent infections occurring before harvest. Controlling these decays has become a new frontier for biological control. New approaches utilizing natural fruit wax and artificial membranes were recently developed to find effective antagonists to control latent infections. The regulatory aspect remains the main stumbling block in the greater use of BCPD. High cost of tests required for the registration prohibits commercial development of several effective biocontrol agents. A new framework is needed for streamlining registration of low-risk biocontrol agents, especially those that are naturally occurring on fruit surfaces. The Minor Use Registration (IR-4) program has been the best vehicle for expanding registration of currently available products for new commodities, and the continuous expansion in use of BCPD testifies to growers' acceptance of this approach.

How to Increase Conversion Rate to Organic Fruit Production

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The region called “Altes Land” located in the north of Germany has approximately 10,000 ha of traditional fruit growing. Located right in the middle of the region is the central research, advisory and education facilities called ESTEBURG at Jork, near Hamburg. Within the past 10 years, nearly 10 per cent of the orchards in “Altes Land” converted to organic farming. This is a significantly higher rate of conversion than in other agricultural sectors in Germany and other European countries. The unique network of research, on-farm trials, advisory service and the farmers themselves was the primary reason for encouraging and enabling farmers to convert to organic production. Organic fruit farmers founded a voluntary consulting association which funds an advisor, who organizes group meetings where knowledge is passed from farmer to farmer, advisor to farmer and farmer to advisor. Together they identify problems to be solved and the advisor takes the questions raised back to the researchers who can help address them. Research trials are set up on the farms of the members. Results from the trials are immediately available to the growers and the experimental design can be fine-tuned according to the needs of the farmers. This ecological advisory association is working very closely with the conventional advisory association. Due to hesitation of conventional farmers, there is often a high emotional threshold to overcome to enable dialogue with colleagues practicing organic farming. The key to success is based on the high level of cooperation between the two advisory associations, the close contact with the researchers, the open exchange between farmers, and last but not least, the economic success of organic fruit growing in northern Germany.