

Cultivating Biological Connections

Proceedings of the Northwest Symposium on Organic and Biologically Intensive Farming: Advances in Research and Education



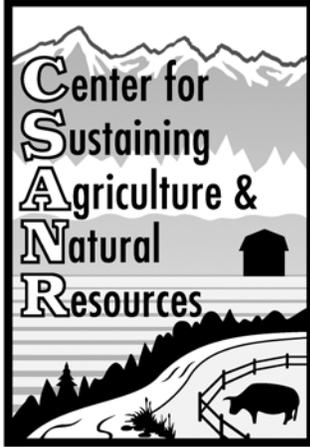
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Poster/Page No. indicates the page number in the proceedings where poster summaries can be found and the location of the poster in the conference room where posters can be viewed.

COMPOST **Poster/Page No.**

What Does Compost Analysis Tell You About Your Compost?-----1

Andy Bary, Craig Cogger, and Dan Sullivan

Biodynamic Compost Preparations Speed Composting and Increase Nitrogen-----2

Lynne Carpenter-Boggs, Jennifer Reeve, and John P. Reganold

Impact of Raw and Composted Dairy Manure Amendments on Sweet-----3
Corn Root Rot

Heather Darby, Alex Stone, Michelle Wander, and Richard Dick

Estimating Plant Available Nitrogen From Composted and Uncomposted-----4
Organic Materials

Eric Gale, Dan Sullivan, Del Hemphill, Craig Cogger and Andy Bary

Organic Amendments in Greenhouses: A Challenge for Organic Agriculture-----5

C.J.Koopmans, E. Heeres and W. Voogt

Recommended Application Rate of Dairy Manure Compost for Vegetable Crops-----6

Craig MacConnell, Daniel Coyne, Todd Murray, Craig Cogger and Andy Bary

CROPPING SYSTEMS

Sustainability of Three Apple Production Systems: Organic, Conventional, and-----7
Integrated Past Results, Current Research, and Future Objectives

Gregory M. Peck, Jerry D. Glover, Preston K. Andrews, John P. Reganold and
Herbert R. Hinman

Biologically Intensive Dryland Farming in the Intermediate Rainfall Zone of-----8
Eastern Washington

Dennis Tonks and Darla Rugel

DISEASE AND WEED CONTROL

Identifying Components for an Integrated Program to Control Raspberry-----9
Root Rot

Peter R.Bristow, Carol A. Miles, John N. Pinkerton and Martin Nicholson

Managing Late Blight on Tomato in Western Washington by Organic Practices-----10

Debra Ann Inglis and Babette Gundersen

DISEASE CONTROL (Cont'd) Poster/Page No.

Mulching Systems for Weed Control, Water Conservation, and Nitrogen Management in Organic Apple Production-----11

D. Granatstein, K. Mullinix and E. Hogue

Field Evaluation of Non-fumigant Measures for the Control of Apple Replant Disease -----12

Mark Mazzola, David M. Granatstein, Don C. Elfving and M. Kent Mullinix

Mustard Green Manures Replace Soil Fumigant and Improve Infiltration in Wheat Potato Cropping System -----13

Andy McGuire

Eastern Filbert Blight in Hazelnuts (Filberts)-----14

Ross H. Penhallegon

Compost Tea as a Potting Mix Drench for Suppressing Damping-off of Seedlings Caused by *Pythium ultimum* -----15

Steve Scheuerell and Walt Mahaffee

EDUCATION

Cultivating Success in Sustainable Small Acreage Farming-----16

Theresa Beaver and Cinda Williams

Center for Sustaining Agriculture and Natural Resources (CSANR)-----17

Cindy Murray-Armstrong and David Granatstein

INSECT CONTROL

Areawide II – 2001 Annual Report-----18

Ted Alway

The Wenatchee Valley Pear IPM Project (WVPP): 1999-2001-----19

Ted Alway

“MagNet”: A Collaboration to Reduce Dependence on Chlorpyrifos Use-----20

Amy J. Dreves, Alex Stone and Shannon Schowalter

Mowing Frequency in Pear Orchards Affects Densities of Natural Enemies in Ground Cover and Tree Canopy -----21

David Horton

Potential of the Granulovirus of *Pandemis pyrusana*: Activity in Lab and Field Studies-----22

L. A. Lacey, K. Becker, H. Headrick, D. Hoffmann, R. Pfannenstiel, T. Unruh and P. Vail

INSECT CONTROL (Cont'd) Poster/Page No.

**Development of Entomopathogenic Nematodes for Control of Overwintering
Codling Moth Larvae-----23**

L. A. Lacey, T. R. Unruh, H. Headrick and J. Upton

Alternative Management Strategies for the Carrot Rust Fly, (*Psila rosae* Fabricius)-----24

D. P. Muehleisen, A. Bary, C. Cogger, C. A. Miles, A. Johnson, M. Nicholson,
T. Carkner and M. R. Ostrom

**Evaluating Arthropod Activity in Organic and Conventional Fields: The role of
Field Margins-----25**

Renée Priya Prasad, William E. Snyder and Deborah E. Henderson

Predator Conservation in Organic and Conventional Potatoes-----26

William E. Snyder and Amanda M. Koss

**Improved Management and Sampling of Garden Symphylans-----27
(*Scutigera immaculata* Newport)**

Jon R. Umble and James R. Fisher

IRRIGATION MANAGEMENT

Quincy Irrigation Trial: Impacting Fruit Quality with Water Management-----28

Tom Auvil

MANAGEMENT AND MARKETING

Emergy Analysis of Food Production at S&S Homestead Farm-----29

Andrew C. Haden

**Export of Organic Food Products to the European Union: Significance
and Barriers-----30**

Rachael Jamison and Brenda Book

“Horsepower Organics” is Horse Powered Organic Agriculture-----31

David and Deborah Mader

Who Cares About Biological Farming Practices?-----32

Jonathan Moscatello and Rebecca Siplak

Insurance Coverage for Organically Grown Insurable Crops-----33

Jo Lynne Seufer

SOIL BIOLOGY

Orchard Floor Management Practices for Improving Soil Quality and Optimizing N Uptake Efficiency-----34

Anita Nina Azarenko, Annie Chozinski, Sarah Finger, Tom Forge, Tim Righetti and
Stefan Seiter

Soil Enzyme Activity as a Sensitive Indicator of Ecosystem Disturbance-----35

R.P. Dick, J. Sandeno, J. R. Wagner, A. Taylor, T. Knight and N. Pascoe

Earthworm Populations and Species in the Palouse of Eastern Washington-----36

Mary Fauci and David Bezdicek

Cover Cropping and Soil Microbial Community Ecology in Western Oregon-----37

Mary Schutter and Richard P. Dick

VARIETY DEVELOPMENT AND TESTING

Dry Bean Varieties for Niche Markets in the U.S.A.-----38

Carol Miles and Madhu Sonde

The Need for Organic Plant Breeding Programs, with Wheat as an Example-----39

Kevin Murphy, Stephen Jones, Doug Lammer and Tim Murray

Development of Open-Pollinated Broccoli Varieties for Local Cropping Systems-----40

Jim Myers, Peter Boches and J.J. Haapala

Lingonberry Variety Trial-----41

Ross H . Penhallegon

The Farmer Cooperative Genome Project-----42

Heather Smith, J.J. Haapala and Pete Gonzalves

COMPOSTING

What Does Compost Analysis Tell You About Your Compost?

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Composts are made and used on organic farms as part of their nutrient management plans. Proper production of composts is important to meet organic certification standards. When compost is purchased it is important to understand the differences in quality between composts to meet your crop production goals. Compost quality can be used to compare composts prior to purchase, to determine how the compost should be used, which compost is best for the your situation and to compare costs. Compost quality is evaluated with sensory, field and laboratory tests. These include color, odor, particle size, pH, salt content, C:N ratio, nutrients and maturity. These factors can tell you how this compost will respond for you. This poster will address chemical analysis of compost for use for organic crop production.

Biodynamic Compost Preparations Speed Composting and Increase Nitrogen

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Biodynamic (BD) agriculture is an organic farming system that relies heavily on compost as a fertilizer. Six herbal preparations are added to composting materials in order to make BD compost. Biodynamic compost maintains a higher temperature throughout the active composting period. At this stage there are indications of greater microbial activity. After active composting, BD compost shows signs of greater maturity and quality, including lower carbon dioxide respiration and greater nitrate content. Microbial communities in BD-treated and untreated composts are significantly different.

Our objectives are to impartially assess the effects (if any) of biodynamic preparations on the composting process and product in farm conditions.

In our first study BD compost preparations were applied to 3.5 ton compost piles made of dairy manure and woodshaving bedding. Control piles received the same handling except for the BD preparations.

In the second study at Fetzer Wineries of Mendocino County, California, the BD compost preparations were applied to 2 windrows with dimensions of 60 x 10 x 7 each (approximately 1245 tons). Raw material consisted of grape pumice, dairy cow manure and straw bedding. The control piles were the same dimensions and received the same handling except for the BD preparations.

Biodynamic-treated composts maintained an average 3.4 C higher temperature in the dairy manure tests. In the dairy manure tests final compost respired carbon dioxide at a 10% lower rate and had a larger ratio of dehydrogenase enzyme activity to carbon dioxide production. Microbial communities in the finished BD piles were significantly different by phospholipid profiles. This examination suggested a higher proportion of bacteria to fungi in the finished BD compost. Final samples of BD-treated composts also had 65% more nitrate than untreated piles. The results from the grape pumice test are currently being analyzed.

Addition of the BD compost preparations increases temperature of composting materials, apparently through stimulation of certain microbial activities. These results suggest that the BD compost preparations might be useful in enhancing the ease or value of composting, although additions of other commercial or non-commercial products may cause similar effects.

Impact of Raw and Composted Dairy Manure Amendments on Sweet Corn Root Rot

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Composted dairy manure solids (MSC) supported biological control of *Pythium* root rots of cucumber in sandy soils in previous studies¹. Biological control was shown to be positively related to microbial activity and to the quantity and quality of MSC-derived particulate organic matter (POM).

The objectives of this work were to 1) determine the effect of fresh and composted dairy manure amendments on root rot of sweet corn (putative causal agents *Pythium arrhenomanes*, *Phoma* spp., and *Drechslera* spp.), and 2) describe the relationships between microbial activity, free particulate organic matter (fPOM), and severity of root rot in a field soil.

A field trial was established on a continuously cropped vegetable field located in Corvallis, OR, in April 2001. Treatments included fresh (MS) and composted (MSC) dairy manure separated solids amended at low (L) and high (H) rates (MS, 16.8/33.6 dry Mg ha⁻¹; MSC, 28.0/56.3 dry Mg ha⁻¹) and an unamended control. Treatments were applied in May and plots were planted to sweet corn "Golden Jubilee" in June. Soils were collected at 2 and 12 months after amendment and assessed for disease severity (container bioassay), microbial activity (rate of hydrolysis of fluorescein diacetate), and fPOM (densitometric separation).

Two months after amendment, HMS, LMSC, and HMSC significantly reduced the severity of root rot of corn relative to the control. HMSC, the most suppressive treatment, generated 64% less disease compared to the control. HMS, the least suppressive, generated 34% less disease compared to the control. There was a strong negative relationship between disease severity and both microbial activity ($R^2 = 0.92$) and fPOM ($R^2 = 0.99$). In addition, there was a strong positive relationship between fPOM and microbial activity ($R^2 = 0.87$). At two months after amendment, treatments with fPOM values above 10.15 mg g soil⁻¹ were suppressive. We hypothesized that this is a fPOM threshold for suppressiveness. However, twelve months after amendment, the HMSC treatment was not suppressive even though its fPOM content was above the threshold. In addition, there were no longer relationships between root rot severity and both microbial activity and fPOM. It is likely that fPOM decomposed for twelve months is too decomposed to support biocontrol even at fPOM levels above the putative threshold. NMR spectroscopic methods will be utilized to determine the composition of fPOM required to support biological control.

Free POM and FDA hydrolytic activity show promise as indicators of soil biological root rot suppressive potential in field soils, but must be tested further.

Reference:

¹Stone, A.G., S.J. Traina, and H.A.J. Hoitink, 2001. Particulate organic matter composition and *Pythium* damping-off of cucumber. *Soil Sci. Soc. Am. J.* 65:761-770

Estimating Plant Available Nitrogen From Composted and Uncomposted Organic Materials

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One barrier for growers in utilizing manures and composts as a source of nitrogen (N) is the uncertainty of how much to apply to meet plant N requirements. Under-application can result in decreased yields while over-application involves unnecessary application costs and negative environmental consequences. Estimation of application rates is made difficult because, by their nature, these materials are extremely variable in their composition and their ability to supply N to plants. Both the timing of N availability and the amount of available N supplied by organic amendments are unpredictable.

The goals of our two-year project are to (1) evaluate N availability of locally-available organic waste streams to supply N and (2) develop simple computer simulation models for future evaluation of organic materials.

We evaluated six organic materials in field and laboratory experiments in the first year of our project: chicken manure, composted chicken manure, dairy solids, composted dairy solids, yard trimmings, and composted yard trimmings. In the field experiment, we applied enough pre-plant organic amendment to supply approximately half of sweet corn N requirements. We included a comparison with urea applied at rates of 0, 50, 100, 150, and 200 lb N per acre. Field experiments were managed using conventional pest and weed control, irrigation, and tillage. In the laboratory experiment, we measured CO₂ evolution and N mineralization for organic amendment samples incubated in moist soil collected from the field sites at 25°C. Several other materials, including on-farm compost, feather compost, and BioGrow pellets, were also included in the lab experiment.

In the first year of the field experiment, total N in plants at harvest (chicken manure > dairy solids and yard trimmings) closely paralleled soil inorganic N levels three weeks after amendment application (chicken manure > yard trimmings > dairy solids). This relative order of N availability in the field was also found in our laboratory experiment, where the materials could be classified into two pools. The fast pool (chicken manure) had high CO₂ respiration rates, low C:N, and net mineralization after 70-days. The slow pool (dairy solids and yard trimmings) had low CO₂ respiration rates, high C:N, and net immobilization or low net mineralization.

Our organic materials varied widely in N availability. One initial conclusion is that the source of material is more important than whether it is composted or not. Chicken manure, feather compost, and BioGrow provided rapid N availability, while dairy solids, yard trimmings, and on-farm compost immobilized or slowly released available N. The second year of this project will repeat similar experiments for a wider range of organic materials, allowing a more comprehensive evaluation of the accuracy of computer simulation models used to predict N availability.

Organic Amendments in Greenhouses: A Challenge for Organic Agriculture

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In the EU the use of animal manure is limited to 170 kg N/ha/year, which means a considerable constraint for organic greenhouses with nutrient outputs from the house at levels of 700 to 900 kg N ha⁻¹ year⁻¹. This makes development of alternatives based on plant composts and additives in these greenhouses necessary.

Three commercial organic greenhouses growing crops like tomato, cucumber and sweet pepper in rotation were monitored for nitrogen levels in the soil, organic matter dynamics, crop growth and manure and residue management for 3 years. At the greenhouses, fertilization experiments were performed comparing the practices of the growers with two treatments; composted cow manure and plant based composts, supplemented with bloodmeal. This on-farm monitoring was combined with laboratory studies on potential mineralization of the soils and fertilizers.

Results show that nutrients added with the compost by growers in many cases exceed nutrient uptake by the crops considerably resulting in a high potential for nitrogen losses. The NDICEA simulation model (Koopmans and Bokhorst, 2002) was able to simulate nitrate levels found in the soil. With the model we identified sources of N available to the plants from the different sources of animal and non-animal based plant nutrient sources. Laboratory tests of compost and manures showed big differences in nitrogen release in time, which is important management information for the growers.

The results show that organic amendments lead to considerable differences in mineralization potentials in organic greenhouses making it difficult for growers to tune nutrient availability to crop needs. The model seems a useful tool to use as an indicator for mineralization especially if combined with measurements of potential mineralization in the laboratory. In two out of the three greenhouses a surplus of nitrogen was found resulting in a risk for nitrogen leaching losses

Reference

Koopmans, C.J. and Bokhorst, J.G. (2002). Nitrogen mineralization in organic farming systems: a test of the NDICEA model. *Agronomie*.

Recommended Application Rate of Dairy Manure Compost for Vegetable Crops

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The dairy industry is a significant component of Whatcom County agriculture where there are currently around 220 dairies and over 80,000 dairy cows. Dairy farmers are now required to manage the amount of phosphorous and nitrogen produced from animal waste in order to prevent nutrient runoff into below-ground waterways. One method that will help limit ground water contamination is the removal of these nutrients off the farm into areas that can benefit from such nutrients, such as home gardens and commercial agriculture. The following research project was designed to investigate a recommended application rate of dairy manure compost for vegetable crops.

Last year (2001) a demonstrative, experimental garden was established at Hovander Homestead Park, located in Ferndale. Over one quarter million people visit this site each year. Beets, bush beans, radishes, spinach, and leaf lettuce seeds were planted into four different pre-plant application rates of dairy manure compost (no compost, 0.3 inches, 3 inches, 6 inches). The garden design was a randomized complete block design with four replications. Vegetables were harvested once the majority of the plots reached marketable maturity. Data collection consisted of various yield-determining measurements, such as stand counts, plot yield, fresh/dry weight, percent moisture, edible root width, leaf length, and chlorophyll content. This growing season (2002) we planted into the same plots using the same crops as last year, but made an application of 0.3 inches of manure compost to all compost amended plots. Data were collected in the same manner. At the beginning of each year, all plots received a pre-plant application of 16-16-16 at a rate of 180 pounds of nitrogen per acre. This was required in order to isolate the impact manure compost has on the soil environment other than as a nutrient source.

2001 data suggested a compost-dose dependant response in yield where 0.3-inches produced the best results in the majority of the crops harvested. There was little significant difference revealed in the radish plots, which may be attributed to their rapid growth rate. Beets performed best under an application rate of 3 inches. Spinach and lettuce crop yields dropped as the rate of compost increased above 0.3 inches. Data collected for the 2002 growing season showed an increase in crop yield as the previous year's compost application rate increased. 3 and 6-inch applications of compost greatly increased yield within the lettuce and spinach plots. Radish yield showed little difference among treatments. Beets produced a higher yield at a compost rate of 6-inches. Bush beans yielded more overall at a rate of 3-inches.

The results of this experiment indicate that 0.3-inches of compost will produce quality results the current year, but higher rates of year old compost inoculated with 0.3-inches of compost the current year performs extremely well. Ultimately, research reported here illustrates that the incorporation of dairy manure compost into the soil has a beneficial impact on crop yield, which is not directly due to nutrient availability.

The dairy industry is a major asset to the agricultural revenue of Whatcom County. Turning dairy waste product into revenue while reducing negative impacts on water quality will contribute to the continuation of this valuable industry. Our goal of this demonstration is to allow home gardeners and commercial farmers to witness the benefits of compost. In tandem, dairy producers are able to recognize a possible consumer of composted waste.

CROPPING SYSTEMS

Sustainability of Three Apple Production Systems: Organic, Conventional, and Integrated Past Results, Current Research, and Future Objectives

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Greater environmental awareness, concern for farm workers' health, and increasing consumer demand for safe and nutritious agricultural commodities has led us to study the sustainability of organic, conventional, and integrated apple production systems. Since the planting of a comparative trial of these three apple orchard systems in 1994, we have published results on soil quality, horticultural performance, economic analyses, environmental impact of agrochemical use, and energy efficiency, finding that the organic and integrated apple production systems were not only economically viable enterprises, but more environmentally sustainable than the conventional system.

Few long-term studies have been conducted on the sustainability of production systems to manage perennial horticultural crops. By defining agricultural sustainability as a farm that produces adequate yields of high quality, is profitable, protects the environment, conserves resources, and is socially responsible, we seek to elucidate the factors that contribute to the overall sustainability of an apple production system. We correlate measures of soil quality, horticultural performance, profitability, environmental impact of agrochemicals, energy efficiency, and nutritional quality of fruit to the sustainability of each production system. Nutritional quality is a new component to this research project and will be evaluated by assessing the mineral, antioxidant, and ascorbic acid (vitamin C) content of the apples.

In 1994, at a privately owned farm in Zillah, Washington (Yakima Valley), four replicate plots for each of the three apple production systems were planted as a high-density orchard of 'Golden Delicious' in a randomized complete block design. Due to market demand the trees were top grafted with 'Galaxy Gala' in 1999 and 2000. A hailstorm destroyed the 2001 crop, therefore 2002 was the first harvest of Gala apples. Management practices were typical for each system in Washington State and were chosen in cooperation with the growers and professional horticulturalists. To better understand the complex interactions involved in growing, storing, evaluating, and marketing apples, our research team includes scientists in the fields of horticulture, soil science, agricultural economics, plant pathology, and food science.

For the 1994-1999 growing seasons, our data demonstrate that organic and integrated apple production systems are not only better for the soil and the environment than their conventional counterpart but had comparable yields and, for the organic system, sweeter apples, higher profits and greater energy efficiency. The organic and integrated systems had higher soil quality and lower negative environmental impact from agrochemicals than the conventional system. No observable differences in pests or diseases had been detected among plots. Reports from this study have been published in peer-reviewed journals (*Nature* and *Agriculture, Ecosystems and Environment*), industry journals (*Good Fruit Grower* and *Fruitticoltura*), an extension bulletin, and presented at numerous grower and international scientific meetings.

Our results indicate that the organic system ranked first in overall sustainability, the integrated system second, and the conventional system last. Coupled with the increasing number of consumers purchasing organic and integrated produce, our study shows that these alternative practices are a viable and perhaps necessary direction for apple production in Washington State. Future results from this study will allow for better understanding of the long-term effects of these production systems on environmental and economic sustainability, farm workers, and consumers.

Biologically Intensive Dryland Farming in the Intermediate Rainfall Zone of Eastern Washington

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The traditional winter wheat-summer fallow cropping system commonly practiced in eastern Washington has led to many production and environmental problems. In other parts of the country, direct seeding or no-till practices have been widely adopted. These biologically intensive systems take a holistic approach to production including crop rotation, soil biological systems, weed management, and intense cultural management. In 1997, growers from Lincoln County traveled to Pierre, South Dakota to see direct seeding research that has revolutionized dryland farming in that and other areas of the Great Plains. Farmers there, formerly using a wheat-fallow rotation, have widely adopted annual cropping with diverse crop rotations. These growers returned believing that direct seeding had great potential to prevent soil erosion; improve air, soil, and water quality; add flexibility and diversity to their crop rotations; expand control options for weed, disease, and insect pests; and increase farm profit. A public-private research project modeled after the South Dakota system was proposed for the WSU Wilke Research and Extension Farm located near Davenport, WA.

The objectives of the project were: a) demonstrate the adoption of diverse crop rotations in direct seed systems that promote natural resource stewardship through reduction of soil erosion by wind and water, b) diversify crop rotations grown in the intermediate rainfall areas of the PNW, and c) implement integrated pest management practices under direct seeding conditions.

Two crop rotations were initiated in 1998 at the WSU Wilke farm and on five cooperator's fields within a 40-mile radius of Davenport. A large portion of the Wilke farm was placed into replicated plots representing a 3- or 4- year rotation. The 3-year rotation is an extension of the traditional winter wheat-spring grain-fallow rotation commonly practiced in Lincoln County. This rotation is winter wheat-spring cereal-broadleaf. The 4-year rotation was spring cereal-winter wheat-warm season grass-broadleaf. Plot size ranged from 8 to 10 acres at Wilke and 10 to 100+ acres on cooperator farms. Each part of the rotation was present each year. Each cooperator chose either a 3- or 4-year rotation while the Wilke farm had both rotations. All field operations were performed using grower equipment. Data were collected on soil quality, weeds, insects, diseases, crop yield and residue, and economics.

After four years, soil organic matter increased slightly in the top two inches of soil and water and wind erosion was not an issue with crop residue covering the soil. Soil nitrate levels did not increase in the profile over the term of the study. Wild oat and prickly lettuce populations decreased while cone catchfly and downy brome populations increased. Some perennial weeds such as Canada thistle have increased. Weed management was one of the greatest input costs in the project. Crop yields varied from year to year, with the 3-year rotation out yielding the 4-year rotation. Alternative crops such as the warm season grass did not perform satisfactorily and did not appear to have a rotational benefit. There was a rotational benefit from the broad leaf crop, with higher cereal yield following a broadleaf compared to following a cereal.

DISEASE AND WEED CONTROL

Identifying Components for an Integrated Program to Control Raspberry Root Rot

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It is unlikely that a single treatment or practice will provide adequate control of root rot of red raspberry caused by the soil-borne fungus *Phytophthora fragariae* var. *rubi*. Our approach is to develop an integrated control program that combines several methods and practices with each contributing to the reduction of damage from this serious disease. To date, we have demonstrated that growing red raspberries on raised beds and in soil amended with high rates of gypsum each improves yield and reduces disease severity.

The objectives of the two field trials reported here were two-fold: 1) to see if soil solarization would delay the onset of the disease in new plantings and 2) to test two biological pesticides and dairy manure for disease suppression in established fields.

The trials were carried out at the WSU Vancouver Res. & Ext. Unit where the soil is naturally infested with the root rot fungus. A randomized complete block experimental design was used and treatments were replicated four times. Individual plots were 25 feet of row. All data were statistically analyzed.

In the first field trial, the soil was worked to a seedbed texture and irrigated to field capacity prior to solarization. Plots to be solarized were covered with a clear polyethylene tarp from late July to late September 1998. Plants of two susceptible varieties were planted in May 1999. Soil in some of the solarized and non-solarized plots was treated twice yearly with the fungicide Ridomil Gold. Plant growth and survival were measured during the year of planting and in 2000 (canes were cut off at ground level in fall 1999). Plots were harvested (by hand) for yield in 2001. In the second field trial, plots in an established 'Meeker' planting were treated in 1999. Treatments included; *Trichoderma* (T-22), *Gliocladium* (G-41), dairy manure (with and without T-22), gypsum, Ridomil Gold and an untreated check. Plots were hand harvested in 2000 and 2001 and were mechanically harvested in 2002.

During solarization, maximum and mean soil temperatures at a depth of 4 in. were 118 and 85 F, respectively. Temperatures at that depth exceeded 105 F for >91 hr. By the end of the planting year, plants in the solarized plots were significantly larger than those in non-solarized plots. Solarization also suppressed weed growth during that first year. Plants in solarized soil out-yielded those in non-solarized soil with or without Ridomil Gold. Dairy manure alone was the only treatment to significantly increase yield in the first harvest year. During the second and third harvest years there were no significant differences between the treatments. Numerically, total yield for the tree year period 2000-02 was highest for the treatments G-41 and Ridomil Gold and lowest for the untreated check.

Soil solarization delayed the onset of root rot for two years. Although western Washington has a maritime climate, there is sufficient sunshine from mid to late summer to raise soil temperature enough to suppress disease in new plantings. Efforts continue to identify the most effective combination of soil organic amendments and biopesticides for use in an integrated root rot control program.

Managing Late Blight on Tomato in Western Washington by Organic Practices

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Although some copper-containing products are registered for use as foliar sprays against late blight in organic tomato production, most efficacy studies show that coppers are not as effective as other fungicides in managing new strains of the late blight pathogen, *Phytophthora infestans*. However, copper materials could possibly be integrated into organic late blight control programs with satisfactory results now that improved levels of late blight resistance are available. One tomato cultivar, *Legend*, developed by Dr. Jim Meyers at Oregon State University, has high levels of foliage resistance to late blight. First year results using the resistant *Legend* and the susceptible *Siletz* indicated that, at least under moderate disease pressure, fungicide spray programs with copper hydroxide were comparable to programs with daconil in managing late blight on tomato fruit, and particularly tomato foliage.

We compared four fungicide spray programs (organic, reduced sprays, conventional and none) on late blight resistant and late blight susceptible tomato cultivars. Tomato plants of two cultivars, one resistant (*Legend*) and one susceptible (*Siletz*) to late blight, were field transplanted on June 6, with eight plants per plot (four plants per cultivar), using four treatments replicated four times in a randomized complete block design. Treatments included a standard and organic late blight spray application every 7 days; stretched spray intervals at 7, 14, and then 21 days; and, a non-treated control. Ratings for foliar late blight were 8/13, 8/20, 8/23, 8/30, 9/6, 9/16 & 9/20. Harvest dates of ripened fruits were 8/22, 9/6 & 9/20. Total rainfall Jun 6-Sep 20 was 4.45 in. with 75.5% occurring before Jul 31; rainfall was 0.35 in. during Aug, and 0.74 in. from Sep 1-20. Supplemental irrigation with drip tape delivered an additional 4.5 in. Jun 21-Aug 23. Spray programs were compared by evaluating AUDPC, total yield, and blighted fruit. There was a significant interaction between cultivar and spray program; thus, data were analyzed by cultivar.

Although control plots were blighted at the end of the season, movement of the disease in the plots was relatively slow, likely due to weather or pathogen genotype (genotype will be verified by cellulase acetate electrophoresis this winter). There were no significant differences among treated and control plots for *Legend*, indicating that during the 2002 growing season or a similar growing season, the improved level of late blight resistance in *Legend* might warrant none or few fungicide applications, particularly if cultural practices to control late blight were employed. A previous study has indicated disposition of *Legend* to fruit blight if environmental conditions are favorable. By contrast, control plots of *Siletz* had significantly higher AUDPC values on both foliage and fruit compared to treated plots. Even in a year with only moderate disease pressure, *Siletz* would likely require intervention with some type of fungicide program to reduce blighted leaves, and fruit (from 30 to $\leq 3\%$ in this study). Although no statistical differences existed among the fungicide programs, copper hydroxide treatment resulted in the highest levels of fruit disease. Fruit yields among all treatments did not differ significantly although the conventional program on *Legend* had lowest yield. Cultivar choice is extremely important for successful management of late blight on tomato especially when a reduced sprays strategy or an organic spray program with copper hydroxide is planned.

TABLE 1.

Treatment and product/a	Foliar AUDPC ^a		Fruit AUDPC		Total yield (cwt/A)		% Blighted fruit (across harvests)	
	Legend	Siletz	Legend	Siletz	Legend	Siletz	Legend	Siletz
Foliar fungicide program								
None	4.4	33.0 b	18.0	231.0 b	1223	1204	2.0	29.5 b
Conventional with daconil 2 lb/a	2.6	2.6 a	2.0	4.4 a	1086	1213	0.3	0.6 a
Organic with copper hydroxide 3 lb/a	2.7	6.6 a	39.0	33.9 a	1124	1161	2.7	3.1 a
Reduced-sprays with daconil 2 lb/a	6.2	7.8 a	4.7	15.0 a	1139	1238	0.3	2.2 a
LSD ($P=0.05$) ^{b, c}	NSD	8.58	NSD	108.74	NSD	NSD	NSD	14.16

^aArea under disease progress curve values. ^bNumbers within a column followed by the same letter are not significantly different as determined by least significant difference (LSD) test. ^c P value is for analysis of variance.

Mulching Systems for Weed Control, Water Conservation, and Nitrogen Management in Organic Apple Production

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Non-chemical weed control that maintains soil quality is a priority need for organic orchardists in many regions. Mulching systems offer the potential for adequate weed control along with benefits for water conservation and soil fertility in Washington State and British Columbia irrigated orchards. Studies were conducted in Wenatchee, WA, to determine the effects of various mulches and cover crops on weed control, tree growth and yield, and soil moisture.

An initial field trial in a 4-yr old 'Red Delicious' apple (*Malus domestica* Borkh.) block compared 8 mulching treatments applied to the tree row (5 replicates): control (weed free), wood chip, shredded paper, chopped alfalfa (*Medicago sativa* L.), winter 'Wheeler' rye (*Secale cereale* L.), Oriental mustard (*Brassica juncea* L. 'Pacific Gold'), and dwarf white clover (*Trifolium repens* L.). Tree growth, tree nutrient status, yield, fruit quality, and soil properties were monitored for 3 years. A second trial with 5-yr old 'Gala' apple compared the effect of wood chip mulch versus no mulch in the tree row (4 replicates) on soil moisture status over 2 seasons using an Enviroscan continuous soil moisture monitor at 10, 20, 30 and 50 cm depths. In Year 1, all plots received the same irrigation; in Year 2, plots were watered according to need. The soil in the trials was a 'Pogue' fine sandy loam (Aridic Haploxeroll) with fine gravel, low organic matter, and low water holding capacity.

Wood chip, shredded paper, and white clover all provided similar and acceptable weed control. Chopped alfalfa led to an increase in weeds, and provided excess nitrogen to the trees through the second season after application. By Yr 3, both wood chip and shredded paper plots were exhibiting nitrogen deficiency, while trees in clover plots were increasing in leaf N content. Higher N treatments generally led to increased tree growth, higher fruit yield, and lower fruit firmness and color. All mulches tended to conserve soil moisture relative to the control, including the clover living mulch. Wood chips reduced soil moisture depletion and irrigation by 20-30% relative to the control. Clover plots were monitored for N release following mowing and appear capable of supplying 20-30 kg/ha N per mowing. Rodent activity increased significantly in the clover plots but in no others. Treatments did not affect soil organic carbon or bulk density, but water infiltration was increased by alfalfa, paper, and wood chip. Mulches tended to keep soil temperatures cooler than the control in spring, but this did not influence bloom development.

In-row mulching of fruit trees can provide a feasible weed control approach that may also benefit soil and water relations. Wood chips provided good weed control and tree growth with the least maintenance, but will need additional N inputs over time. A white clover living mulch provided good weed control, conserved soil moisture, and contributed N to the tree; however, rodent control is a major barrier to this system. Funding was provided by the Washington Tree Fruit Research Commission.

Field Evaluation of Non-fumigant Measures for the Control of Apple Replant Disease

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Apple replant disease is found in many parts of the world. However, the cause is not always well-known and may vary among regions. In Washington State, replant disease is caused by a complex of four fungal pathogen genera *Cylindrocarpon*, *Phytophthora*, *Pythium* and *Rhizoctonia*, with variation in their relative contribution to disease development among orchards. The lesion nematode, *Pratylenchus penetrans*, which has been implicated as a primary causal agent in other regions, can have a significant site-specific role, but more commonly is not involved in disease development. We have been evaluating various cultural, biological, and fungicide controls for the ability to suppress the causal pathogen complex and enhance growth and yield of apple on replant sites. Alternatives to soil fumigation are being sought.

Field trials were established in 1997, 2000, and 2001 in the Wenatchee area, using Gala/M.26 apple. Treatments included commercial and developmental biocontrol agents, semi-selective fungicides active against pythiaceus fungi or *Rhizoctonia* spp., and cultural practices including soil disturbance, solarization (6 mil clear plastic), wheat cover crop (Penewawa; 336 kg/ha), and *Brassica napus* seed meal (6375 kg/ha). Trials used a randomized complete block design with 3 replicates.

Altering spatial patterns in the orchard, use of specific fungicides that targeted multiple elements of the causal fungal complex, or soil excavation in the fall prior to planting each enhanced yields at the Columbia View orchard (Table 1), while biocontrol agents showed no effect. Establishment of new trees in the old orchard drive row (aisle) rather than the old orchard tree row resulted in an initial increase in fruit yield. Soil solarization during the summer prior to planting (2001) and all treatments that incorporated *B. napus* seed meal amendment significantly improved first year vegetative growth of apple. Based on the rates employed as well as leaf and soil analyses, the seed meal response is probably not the result of enhanced plant nutrition.

Wheat cultivation prior to apple planting was less effective in the field than in the greenhouse, perhaps due to inadequate availability of N, which was dramatically reduced in soils after wheat cropping. When combined with *B. napus* seed meal, the effect was influenced by the sequence of treatment. With seed meal/wheat, there was a trend for increased tree growth at one site compared to wheat/seed meal. In greenhouse trials, the latter produced a better growth response in soils with high levels of *P. penetrans*.

Results from this study suggest that the integration of certain cultural practices and narrow-spectrum biocides have significant potential as alternatives to pre-plant soil fumigation for the control of apple replant disease. Recommendation of such methods awaits confirming yield data from field trials in progress and development of guidelines for issues such as the appropriate application sequence.

Table 1. Effect of cultural, biological and chemical methods on yield of ‘Gala’/M.26 planted on replant ground in 1998 at Columbia View orchard, Orondo, WA

Treatment	2000 yields (kg/tree)	2001 yields (kg/tree)
Control	4.6	20.64
Methyl bromide fumigation	7.2*	27.12*
Soil excavation	5.4	25.72*
Interplanting (aisle)	6.4*	^y
<i>Pseudomonas putida</i> 2C8	4.1	21.36
RootShield® (<i>T. harzianum</i>)	4.7	22.45
Difencnazole	3.4	23.71
Metalaxyl+flutolanil	4.5	29.1*
Humic acid	3.4	19.9

^zMeans in a column followed by (*) are significantly different ($P=0.05$) from the control.

^yTrees removed from the aisle October 2000.

Mustard Green Manures Replace Soil Fumigant and Improve Infiltration in Wheat-Potato Cropping System

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Mustard green manure crops (*Sinapis alba* L. and *Brassica juncea* (L.) Czern.) have the potential to improve soil-borne pest control and soil quality in potato cropping systems. However, potato farmers are often reluctant to use these crops because it is unclear whether the pest control benefits outweigh the costs of producing the crop. It is also difficult to evaluate the value of improved soil quality. Therefore, if these crops are to be adopted, the economic benefits must be clear and the benefits of improved soil quality must be documented. Many Washington potato farmers apply the fumigant metham sodium for control of *Verticillium dahliae*, costing them \$140-200/ac. They also often have problems with water runoff because their center pivot irrigation systems often operate above the infiltration capacity of their soils.

On-farm research trials were conducted to determine whether the use of mustard green manures could eliminate application of metham sodium and increase water infiltration rates in a spring wheat (*Triticum aestivum* L.) - potato (*Solanum tuberosum* L. cv. Russet Norkotah) cropping system.

Three trials were conducted following spring wheat, two using *S. alba* cv. Martigena (1999 and 2000) and one using *B. juncea* cv. Cutlass (2000). The green manure crops were fall-incorporated and potatoes, with and without metham sodium, were planted the following spring at Moses Lake, WA, on Timmerman loamy sands and sandy loams. Yields were measured in the fall and soil infiltration rates were measured at various times over three years.

Aboveground biomass yields for the mustard were 5848 and 4773 lb dry matter/ac for Martigena (1999 and 2000, respectively) and 5043 for Cutlass (2000). Subsequent total potato yields averaged 31.6, 34.3, and 31.6 tons/ac, respectively, for the three trials with no significant differences between fumigated and non-fumigated treatments. For the three trials, 82, 88, and 88 % of tubers met the US#1 grade (>4 oz). In 2001, potato yields were obtained with just 160 lb N/ac applied in season suggesting uptake by the potato crop of N released from the green manure crop. In 5 of 6 comparisons, infiltration rates for soils receiving mustard green manures were from 2 to 10 times greater than those in adjacent soils not receiving green manures. Cash production costs for the mustard were estimated to be \$91/ac.

With this cropping system, potato farmers could save from \$49-109/ac by using mustard green manures to replace metham sodium while also improving the rate of water infiltration into their soils. Additional savings could be seen if the N released from the green manure crop replaced some of the fertilizer N normally applied to the potatoes.

Eastern Filbert Blight in Hazelnuts (Filberts)

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Eastern Filbert Blight (EFB) is a disease that has infected orchards between Vancouver, Washington and Keizer, Oregon. The disease is destroying hazelnut (filbert) orchards; the disease needs to be controlled before it spreads into the south valley (area south of Keizer). EFB is spreading from infected nut trees and ornamental filbert trees into trees in the quarantine area and outside the quarantine area. Of the 29,140 acres of hazelnuts, over 10,000 acres are infected or near infected orchards. Infected trees need to be prevented from entering the south valley. Since May 1990, there have been over 163 contorted filbert trees shipped into the south valley.

Filbert production is an important agricultural activity in the Willamette Valley:

Lane County has 3,250 acres with income of \$2,750,000

Linn County has 1,365 acres with income of \$1,350,000

Benton County has 425 acres with income of \$ 410,000

In this industry, annual gross farm value of the crop is \$19,847,000 statewide.

Eleven growers meetings have been held to inform growers of the problem, involve them, and solicit ways of dealing with the disease. Growers are intensively inspecting their own orchards. The public was advised to have any contorted filbert trees inspected for EFB.

In a joint effort with the Oregon Department of Agriculture (ODA), Oregon State University, the local Extension Services and the Oregon Hazelnut Commission, 334 trees have been inspected for EFB in the three county areas. There have been 46 news articles, 10 radio spots and 11 television shows helping to make people aware of this problem. News articles have reached over 801,000 people in the tri-county area.

Over seventy percent of hazelnut growers have attended a program on EFB. During the media coverage, growers and the public have been intimately involved. One hazelnut grower took the time in the winter to drive around looking for the unique yellow catkin on contorted filbert trees and reported 8 uninspected contorted filbert trees.

A grower who is a utility employee, while making inspections, located a contorted filbert tree and reported it. Even a package delivery employee delivering parcels in the county spotted a contorted filbert tree and reported it. In the last set of inspections, 50% of the trees had already been inspected once and most of the trees were old, established trees.

As a result of outstanding community support, 21 severely infected contorted trees were found and destroyed. Through excellent media coverage, involved growers and concerned citizens, infected trees have been removed and the southern hazelnut industry is disease free.

We learned that through good public relations, teaching growers and the public about the importance of this disease that we were able to not only find all of the infected contorted filbert trees, but were able to find trees which were illegally brought into the county.

Compost Tea as a Potting Mix Drench for Suppressing Damping-off of Seedlings caused by *Pythium ultimum*

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Damping-off of greenhouse propagated seedlings, commonly caused by *Pythium ultimum*, is a common problem facing growers. This is especially true with a peat-based potting mix that does not naturally suppress damping-off. There is increasing interest in the potential for compost tea to suppress damping-off, particularly among certified organic growers that have few approved control measures. In this study we examined the potential for compost tea to suppress damping-off caused by *P. ultimum*, with a focus on the role of aeration and added nutrients during compost tea production.

Non-aerated compost tea (NCT) was produced in a 19-L bucket by mixing 15-L water (20-22 C), 500-g compost (approximately 50% moisture w/w) and optional fermentation nutrients; the contents were then left undisturbed for 7-9 days until used. A Bio-blenderTM (Soil Soup, Inc., Edmonds, WA) was used to produce aerated compost tea (ACT) in a 19-L bucket with 15-L water (20-22 C), optional fermentation nutrients, and 500 g compost held in a 100 μ m mesh filter bag; compost tea was used after 36 hours of aeration. Fermentation nutrient recipes were 1) molasses-based 'Bacterial' nutrient solution (Soil Soup, Inc.) (0.5%, v/v) and 2) 'Fungal' recipe per L water 1.2 g powdered soluble kelp (Maxicrop), 2.5 ml liquid humic acids (Humax), 3 g glacial rock dust (Gaia). Bacterial populations of compost tea were measured as active cells/ml, total cells/ml and colony forming units/ ml. Compost tea and water as a control treatment were drenched onto six replicate pots filled with *P. ultimum* inoculated peat-perlite growing media and eight cucumber seeds each. Drenched pots were placed in a growth chamber (20 C, 16 h photoperiod) and assessed for the number of healthy cucumber seedlings after nine days. Experiments were randomized complete block designs, two-way ANOVA was performed with treatment means separated by least significant difference (*P* value 0.05)

Compost tea made without fermentation nutrients did not suppress damping-off. Both NCT and ACT made with fermentation nutrients suppressed damping-off. ACT made with the 'fungal' nutrients consistently suppressed damping-off over repeated trials. ACT made with the molasses-based fermentation nutrient had the greatest active, total, and culturable bacterial populations but was associated with erratic damping-off suppression over repeated trials. Separate experiments indicate that at little as 0.01% molasses added to suppressive compost tea negates suppression.

Compost tea can be used to control *P. ultimum* damping-off of cucumber in peat-based growing media that is naturally conducive to the disease. Both ACT and NCT significantly reduced disease with the addition of fungal fermentation nutrients being the most consistently suppressive. For *Pythium* damping-off suppression, it is not recommended to use molasses in the production of compost tea. Commercial scale greenhouse trials are needed to evaluate compost tea drenches as a viable disease control tool.

EDUCATION

Cultivating Success in Sustainable Small Acreage Farming

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Cultivating Success is a new community-based education program focused on sustainable small acreage farming and ranching. It was developed as a collaborative project between University of Idaho, Washington State University and Rural Roots (a non-profit organization of Inland NW small acreage farmers). Cultivating Success focuses on quality education in the food and agricultural sciences and provides students with a program that is: experiential on farms, mentored by farmers & ranchers, interactive with agricultural professionals and applicable towards a range of career goals. Cultivating Success offers a unique combination of experiential learning and community-based education. Graduates will bring their on-farm experience and systems approach to food and agriculture to bear in their future endeavors - as farmers, ranchers, agricultural professionals and consumers. Those entering the policy arena will have a solid understanding of the sector in which they are working.

The Cultivating Success certificate program, currently in its pilot year, includes a series of courses and an on-farm apprenticeship. Courses are currently being offered at two sites: Moscow, Idaho (UI/WSU) and Puyallup, Washington (WSU). Each course focuses on "real world" experience and features farmers and professionals as guest instructors. Courses offered as part of the Cultivating Success curriculum include:

- Science, Society and Sustainable Food Systems I - An introductory course to sustainable food systems providing global perspectives and local examples of food system issues.
- Principles and Practices of Small Acreage Farming and Ranching – A production-based overview of successful, sustainable small acreage farming and ranching enterprises.
- Agricultural Entrepreneurship - A business planning and market development course using experienced practitioners from the community & region.
- On-Farm Apprenticeship - A 270-hour on-farm apprenticeship with a trained farmer-mentor providing hands-on experience in the student's area of interest.
- Sustainable Food Systems II - This sustainable food systems course is designed for upper level students to enhance skills of teamwork, problem solving and working in complex systems

Through this combination of community-based classroom education and hands-on experiences, students will gain an in-depth understanding of a selected farm or ranch enterprise including farm business planning, goal setting and innovative marketing strategies. Curricula, instructional videos, distance education support systems, and instructor training workshops are currently being developed and refined. Eventually, the program will be offered through additional institutions of higher education in Washington and Idaho. At a national level, the program will provide a replicable model for innovative sustainable small acreage farming and ranching curricula design, program delivery, student experiential learning, and instructor training.

Center for Sustaining Agriculture and Natural Resources (CSANR)

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The Center for Sustaining Agriculture and Natural Resources (CSANR) works to create sustainable agriculture and natural resource systems that provide a high quality of life for the people of Washington. The CSANR leads in developing and implementing interdisciplinary systems-oriented research and education programs at WSU. Its faculty help bring together teams within WSU and in partnership with other organizations to conduct research and provide education on emerging issues. Activities are funded entirely by external grant funds. The challenges presently facing agriculture in Washington State reflect global concerns about food production, climate change, soil and water protection, farm profitability, and the health of rural communities. Examples of CSANR's systems-oriented research and education programs include:

- The CSANR is developing a program on *Biologically Intensive & Organic Agriculture* (BIOAg). The need for a more sustainable agriculture will require greater reliance on biological processes that are renewable, non-polluting, and provide multiple benefits to farmers and society. The goal is to create a comprehensive research and education program that will provide new educational options for students, needed research for growers, and associated extension support.
- Andy McGuire, the Lauzier Agricultural Systems Educator based in Ephrata has been working with several Grant County growers and other researchers to understand the potential for mustard green manure crops to improve potato production. The practice shows promise in improving soil quality, recycling nutrients, and reducing disease pressure.
- Dryland cereal producers are benefiting from the direct seeding research at the WSU Wilke Farm in Davenport. Data from the first four years show a slight increase in soil organic matter, greater water infiltration into the soil, and less soil erosion according to Dennis Tonks, the CSANR faculty member leading the effort.
- Collaborative problem solving for natural resource issues is a focus of Don Nelson's work with CSANR. He has initiated the Creating a Sustainable Future for Fish, Water and People (FWP) project to build capacity in communities and groups across the Pacific Northwest for resolving complex and contentious issues revolving around restoring endangered species of fish and wildlife, cleaning up our waters, and fostering healthy and sustainable communities and economies.
- Marcy Ostrom, CSANR Small Farm Program Leader, is busy with a major direct marketing study, and teaches a seminar on managing farmers' markets as well as business planning and creative farm marketing through two courses, "Tilling the Soil" and "Cultivating Success". These courses teach new and transitioning farmers the basics of developing business concepts, doing market research and designing and implementing business plans.
- Food safety is the topic of a new project involving Carol Miles, CSANR Agricultural Systems Specialist at Vancouver. The project, *Improving Microbial Safety of Northwest Fresh and Processed Berries*, is led by scientists at Oregon State University and will assess, identify and address microbial contamination risks of fresh and processed berries from farm to fork.

INSECT CONTROL

Areawide II – 2001 Annual Report

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The Areawide II (AWII) program is investigating the use of new pest control and pest monitoring methods in Washington apple and pear orchards. With funding provided by the Washington State Tree Fruit Research Commission and two federal government grants, 15 apple and six pear sites were established in the spring of 2001 in major fruit growing districts of Washington. These blocks will be monitored over the four-year duration of this program to follow changes in pest and natural enemy populations over time. Seven tree fruit pest management consultants, with assistance by Washington State University Tree Fruit Research and Extension Center (WSU-TFREC) and the United States Department of Agriculture Yakima Agricultural Research Laboratory (USDA-YARL) personnel, collected the data on pests and natural enemies at all sites.

Each site was treated with codling moth mating disruption. Within each site, supplements to CM mating disruption were either conventional insecticides (organophosphates) or selective insecticides (non-OP supplements, e.g., oil, Intrepid, Esteem, granulosis virus). Controls for other pests followed a “traditional conventional” approach or a “selective alternatives” approach.

Significant findings:

- There was no difference in fruit damage by CM, San Jose scale, bugs or lacanobia fruitworm in apple sites between organophosphate (OP) or non-OP supplements to mating disruption-based programs.
- There was significantly less fruit damage in programs using non-OP supplements compared to those using OPs.
- There was significantly less feeding by larvae of leafrollers and lacanobia fruitworm in programs using non-OP supplements compared to those using OPs.
- There was no significant difference in the cost of the pheromone-based pest management programs in apple whether supplemented by OP or non-OP products.
- Monitoring with non-pheromone lures for CM, leafrollers and lacanobia fruitworm has established a database from which greater understanding of the value and utility of these tools will arise.
- There were no differences in populations of secondary pests or their natural enemies in programs using OP or non-OP supplements.
- In pear, there appeared to be no differences in psylla populations in the treatment regimes imposed over a pheromone-based pest management program.

The Wenatchee Valley Pear IPM Project (WVPP): 1999-2001

Ted Alway, T.C.Alway Consulting, Peshastin, WA.

The WVPP demonstrated that biological control of key pests in Wenatchee Valley pear orchards could be increased by developing pest management programs that are equally or more effective and economical than the chemically intensive programs commonly used. Sixteen D'Anjou pear growers participated over the three-year period, with over half of the orchards each year using a soft (no or very limited use of broad-spectrum insecticides) or organic pest management program. Pear psylla populations were higher in the soft blocks in the first year, but declined in subsequent years to levels similar to the conventional blocks. Grape mealybug and spider mites were lesser problems in the soft blocks. Pear rust mite increased in many soft blocks. Other pests were at similar levels between the two treatment regimes. Natural enemies were far higher in the soft blocks; the principal ones found were *Deraeocoris brevis*, *Campylomma verbasci*, lacewings, earwigs and *Trechnites sp.* Fruit marking was higher in the first year in the soft blocks, due to pear psylla, but damage levels were similar in later years. Pest control costs averaged \$150-\$200/ac less each year in the soft blocks. Proximity to native habitat is important to pear orchards trying to attract and retain natural enemies. The expansion of soft pear pest management programs is limited by the lack of critical numbers for pests and natural enemies, the limited personnel available to collect and interpret monitoring data, and the greater risk of fruit marking.

“MagNet”: A Collaboration to Reduce Dependence on Chlorpyrifos Use.

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Brassicaceae growers are highly dependent on chlorpyrifos (organophosphate; Lorsban), for control of an important pest, the cabbage root fly (CRF; cabbage maggot; *Delia radicum* (L.)). The threat of its loss and environmental scrutiny has increased grower willingness to test and adopt new management strategies.

As a result of evaluating the cabbage maggot pest situation in root crops in Oregon, a program was developed called "MagNet": a NETwork of people working together to develop a best management strategy targeting cabbage MAGgot management. A strategic plan is being developed to reduce overall chlorpyrifos use, including: practical monitoring techniques (egg scrapes, seasonal flight, mid season damage assessment (M60) spring emergence, and harvest assessments); degree-day modeling; spatial management (GIS field mapping), fall field cultivation methods; enhancement of beneficial organism habitat (e.g straw mulches), and testing of alternative chemistries and application.

The 2002 data indicate that there are four concerted egg-laying periods verified by adult catches in yellow water traps, placement of spring pupae emergent traps, and degree-day modeling. Program staff have selected 3 pilot brassica growers. We have monitored for egg-laying in over 75 fields of these growers fields in 2001 and 2002. This information is proving to better time treatments to high risk periods. Higher proportions of plants with eggs were seen within one quarter mile of a known CRF-source.

An excel-based geographic information system (GIS) is being developed to conduct routine analytical procedures for the growers' management purposes. Lorsban applied in furrows, Fipronil, Mustang (pyrethrin) and Spinosad (bacterial by-product) and film-treated seeds are showing promising results. Emergence of CRF adults has shown to be reduced after fall and spring disking of pupae-infested fields. An IPM continuum rating system (P4Plan) and field risk assessment are being designed to inspire grower interest and adoption of these IPM practices.

Mowing Frequency in Pear Orchards Affects Densities of Natural Enemies in Ground Cover and Tree Canopy

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Pear growers that eliminate broad-spectrum insecticides from their orchards benefit from increased numbers of arthropod predators and parasitoids establishing in the orchard. However, the importance of the ground cover as a habitat for these natural enemies remains largely unexplored. Moreover, the effects of ground cover management, including frequency of mowing, on densities of natural enemies in pear orchards has been pretty much ignored.

Objectives of this study are: (1) document the numbers and types of natural enemies in the ground cover of pear orchards from which organophosphate insecticides have been eliminated; (2) determine how frequency of mowing affects communities; (3) determine whether mowing frequency affects natural enemy densities in the tree canopy.

The study was done at three pear orchards (2 commercial, 1 experimental owned by USDA) in Washington and Oregon. Organophosphate insecticides were not used at any of the 3 orchards. I had three treatments: (1) mowed once every 10-14 days (control); (2) mowed once per month; (3) mowed once (in May) and left unmowed thereafter. Plot sizes were 3 to 7 aisles wide by 30 to 150 meters long, depending upon orchard. There were 3 replicates per treatment at each orchard. Arthropods were sampled every 3 weeks between May and September using sweep nets (ground cover) and beating trays (trees).

Natural enemies in the ground cover were dominated numerically by parasitic wasps, spiders, and predatory true bugs, with fewer numbers of other taxa including syrphid flies, lacewings, and ladybeetles. Reduced mowing frequency led to considerably higher densities of natural enemies in the ground cover, which I attribute to: increased availability of flowering weeds; increased prey availability (especially aphids); reduced direct disturbance. Density increases were noted for virtually all natural enemy taxa, but especially in spiders, parasitic wasps, and predatory true bugs such as minute pirate bugs, big-eyed bugs, and damsel bugs. Even a modest decrease in mowing frequency from once every 10-14 days to once per month led to a 2-3 fold increase in densities of natural enemies. In the tree, reduced mowing frequency led to numerical increases in tray counts for several natural enemy taxa (parasitoids, lacewings, damsel bugs, minute pirate bugs), but significantly so only for two taxa (spiders and a predatory Miridae, *Deraeocoris brevis*).

In conclusion, it is possible to prompt increases in densities of natural enemies in the ground cover of pear orchards - - and to a lesser extent in the tree canopy - - by reducing mowing frequency. Effects on biological control remain to be determined.

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Potential of the Granulovirus of *Pandemis pyrusana*: Activity in Lab and Field Studies

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Grower concerns such as resistance of key lepidopterous pests to insecticides, environmental consequences of conventional insecticides and implementation of the Food Quality Protection Act of 1996 have provided strong impetus for the development of cost effective alternatives to conventional chemical pesticides. Use of codling moth female sex pheromone to disrupt mating has enabled effective control of the moth in the Pacific Northwest with reduced use of conventional insecticides. However, one consequence of mating disruption has been the increase of some leafroller species that are normally controlled by insecticides used for codling moth. Insect pathogens have provided selective control of several major crop pests with minimal impact on humans and other nontarget organisms. One of the most widely used microbial control agents is *Bacillus thuringiensis*. It has been routinely used for control of leafroller species in tree fruit.

The efficacy of the codling moth granulovirus (*CpGV*) has been documented by a number of researchers. The main limitation of this virus is its curtailed persistence on treated surfaces due to degradation by ultraviolet light. Although one of the benefits of *CpGV* is its specificity for codling moth, this is also a limitation for control of other lepidopterous pests. Virus with activity against leafroller species in the Pacific Northwest are available, but not yet developed. Tank mixes of viruses, *Bt* and other applications would enable a more economical means of controlling codling moth and leafrollers simultaneously.

A granulovirus of *Pandemis* leafroller was discovered in Wenatchee that can produce high natural levels of infection. Studies that investigated the effect of *Pandemis* larval age on susceptibility to *PpGV* yielded surprising results: 4th instars were as susceptible to the virus as were neonates, although the onset of mortality was slower. Second instars were the least susceptible in the short run. The increased mortality at lower concentrations observed in the 4th instars was probably a function of the large amount virus-contaminated diet that was consumed. The onset of mortality is both a function of larval age and dosage. Even moderately low dosages result in high mortality when the observation period is extended to 3 weeks. This lingering onset of mortality may cause some concern due to prolonged survival, however there is a significant reduction in feeding by larvae that slowly develop disease symptoms due to consumption of lower amounts of virus.

Application of *PpGV* against 3rd instar larvae resulted in near total reduction of the larvae. Some of the live larvae retrieved from the field 2 weeks after application of the virus eventually died after being held in the laboratory and 25-30% of survivors at the time the test was terminated showed signs of patent infection. Under natural conditions *PpGV* has produced epizootics that resulted in drastic reductions in *P. pyrusana*. Future research is warranted to determine if epizootics can be induced by application of laboratory-produced virus.

Development of Entomopathogenic Nematodes for Control of Overwintering Codling Moth Larvae

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Implementation of the Food Quality Protection Act will reduce the number of pesticides that will be available for control of codling moth and other tortricid pests of apple and other tree fruit in the USA. This and the need to produce a safe supply while protecting the environment provides incentive to develop alternatives to conventional insecticides for control of pest insects. Our research reveals that entomopathogenic nematodes and other microbial control agents have potential as biological control agents of overwintering codling moth larvae under orchard conditions. These insect specific nematodes are safe to vertebrates and most non-target invertebrates and offer unique opportunities for the specific targeting of prepupae of codling moth. The tree trunk habitat and other cryptic habitats of prepupae and pupae offers protected environments in which infective nematodes can better survive while searching for and infecting codling moth.

Infested fruit bins also comprise a significant source of overwintering codling moth. Treatment of bins for control of overwintering codling moth larva prior to placement in orchards, before they are stored or at the time of fruit processing, is not routinely done. Interventions that could be applied to bins that are safe for humans and that are environmentally friendly would be highly advantageous. Our research demonstrates that entomopathogenic nematodes can provide effective and affordable control of codling moth larvae in fruit bins.

Orchard trials – Summer 1998. Orchard trials of *S. carpocapsae* under various moisture conditions were conducted in an apple orchard of mixed varieties using protocols prescribed by Lacey *et al.* (2000). Application of 10^6 IJs/tree using a hand-gun sprayer provided 95% mortality of codling moth prepupae when trees were wetted before application of nematodes and at regular intervals for 6 h after treatment.

Summer 1999. Field trials were conducted in 1999 to compare the efficacy of *S. carpocapsae* and *S. feltiae* using an airblast sprayer and hand-gun sprayer for application of 2×10^6 IJs/tree. For moisture we combined one hour of pre-treatment irrigation with periodic post-treatment wetting of trees by hand. Good control was obtained using *S. feltiae* with both sprayers and fair to moderate control was obtained with *S. carpocapsae*.

Fall 1999. Trials were conducted in September and October using a backpack sprayer (10^6 IJs/tree) to test the effects of autumn temperatures on the two species of nematodes. Moisture was maintained by regularly misting the trees as in the two summer trials. Both species performed optimally in September when temperatures were between 18 and 23° C during the 6 h following treatment. However, in October when the maximum temperature was only 15.2°, *S. feltiae* significantly out performed *S. carpocapsae*.

Spring 2000. Results similar to that reported for fall 1999 were observed in March and April 2000. *S. feltiae* provided better control than *S. carpocapsae* in March when temperatures ranged from 7 to 21°C. Temperatures in mid April enabled good activity for both species. Bin tests. Diapausing codling moth larvae in miniature fruit bins were highly susceptible to IJs of *S. carpocapsae*. Immersion of bins in suspensions of *S. carpocapsae* ranging for 5 to 50 IJs/ml of water resulted in 68-99% mortality.

Alternative Management Strategies for the Carrot Rust Fly, (*Psila rosae* Fabricius)

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Washington State is the number one producer of processing carrots in the U.S. and 4th in the nation for fresh market carrots. As of 2000, about 2% of the carrots grown in Washington were grown organically. Carrot Rust Fly (CRF) is a major pest of carrots in Washington State and can cause significant economic losses. The adult emerges in early spring, eggs are laid at the base of the carrot, and the newly hatched larvae burrows into the soil and feeds on side roots of the host plant during the first two instars. During the third instar, larvae feed on the taproot causing economic damage. This cycle is repeated three times during each season. To avoid CRF damage, organic control options are crop rotation at least every other year, covering the crop with row covers, or delayed planting combined with early harvesting to avoid CRF populations. All the above options are effective, but they each have major drawbacks for the producer.

In the first year of this two-year study we have attempted to develop a monitoring program to predict adult rust fly activity and to determine if underseeded cover crops could be used as economically viable options for reducing CRF damage. Field experiments were carried out in three locations, WSU-Puyallup REC, WSU-Vancouver REU and Terry's Berries organic CSA farm. At both WSU research sites, five different cover crops treatments were compared for their ability to reduce CRF damage and their impact on carrot development and yield. Using a randomized complete block design, we compared harbinger medic *Medicago littoralis*, crimson clover *Trifolium incarnatum*, subterranean clover *Trifolium subtranean*, white clover *Trifolium repens*, and common vetch *Vicia sativa* to no cover crop. To determine the impact of the cover crops on predatory beetle populations, pit fall traps were monitored on a weekly basis at the Vancouver site. Egg, larval and pupal CRF populations were monitored at the Puyallup site. In the on-farm experiment at Terry's Berries we measured the effectiveness of row covers and their impact on yields. Adult CRF populations were monitored on a weekly basis using yellow sticky traps at all three sites and on two farms in northwestern Washington. Yield data were collected at all three sites and the carrots were inspected and graded for CRF damage.

Throughout the carrot growing season, few CRF were captured by the yellow sticky trap and this corresponded with minimal damage to harvested carrots. We were able to demonstrate, as have others, that yellow sticky traps can be used to monitor adult fly activity although CRF populations were low this year. Previous studies have demonstrated that cover crops can reduce CRF damage, however it is unclear if underseeded cover crops will negatively impact carrot yields. Preliminary data suggest that neither underseeding of cover crops or row covers had a negative impact on carrot yields. However, due to the very low population pressure of the CRF this year, we were unable to verify if cover crops reduced CRF damage. Thus cover crops may be a potentially effective tool for integration into an overall pest management strategy but further studies are required to verify this. This work does lay down the foundation for next year's studies, which will include further testing of cover crops, further monitoring of CRF and beneficial beetle populations, and assessment of carrot varieties and USDA breeding lines for CRF tolerance.

Evaluating Arthropod Activity in Organic and Conventional Fields: The role of Field Margins

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Natural enemies can play an important role in the suppression of pests, and for organic growers may sometimes be the only control option. It is important to understand the activity of natural enemies in order to maximize their efficacy as biological control agents. One way to enhance biological control is to provide refuges for beneficial organisms. Field margins can function as refuges; natural enemies move into the margin during the winter and back into the field as the crop develops and pest populations increase. In this study we focused on ground beetles, rove beetles and spiders as these natural enemies are known to be effective predators of a broad range of insect pests.

For two years we have been conducting surveys of ground-dwelling beetles and spiders in both organic and conventional fields. In 2001, our objective was to compare the predator abundance in field margins that had abundant plant cover (grassy) with field margins that had less plant cover and more bare ground (bare ground). In 2002, our objective was to determine the activity of spiders and beetles in fields adjacent to the two types of margins. We also compared conventional and organic fields because we were interested in how agricultural activity, in particular pesticide applications, affected the in-field activity of the predators.

Using pitfall traps, we surveyed the activity of predatory beetles and spiders. Traps consisted of a jar or cup buried in the ground such that the opening was level with the ground. Traps were not baited with an attractant and were used only as a measure of the animals' activity. In 2001, traps were run weekly from late May until late August. Traps were placed along field margins in a 30 m transect, with 3 traps per transect. In 2002, traps were run every three weeks from early April until late July. In each field, three traps were placed in two transects, 10 m apart, each running 20 m from the margin into the field. In both years, all insects and spiders were collected, sorted, preserved and identified.

Results from 2001 demonstrated that beetle and spider activity was initially higher in field margins that had good ground cover, and was particularly high in margins with grass and/or leaf litter cover. Our 2002 sampling program demonstrated in-field predator activity occurred earlier in the season in organic fields with grassy or similarly well-vegetated field margins. Organic fields with bare margins and conventional fields with either grassy or bare margins had lower levels of in-field predator activity. These results support the findings of other researchers who have shown that field margins can be an important refuge for natural enemies in agricultural fields, provided that in-field activities, e.g. application of pesticides, do not disrupt immigrating beneficials.

Our findings show that organic fields with grassy margins supported higher in-field densities of beneficial beetles and spiders. These ground dwelling natural enemies require an abundant layer of ground cover in order to successfully over-winter. This type of habitat can be provided along field margins. The benefit of grassy margins, however, was lost in conventional fields where broad-spectrum pesticides were used under conventional pest management. We are currently conducting additional experiments to address our next question: does the increase in predatory beetle and spider activity in organic fields with grassy margins lead to increased biological control of crop pests such as root maggots, aphids and cutworms?

Predator Conservation in Organic and Conventional Potatoes

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For the last two field seasons we have been sampling predatory insects and spiders in potato fields in eastern Washington. We have been collecting predators from production fields under three types of management: organic, conventional treated with broad-spectrum (“hard”) pesticides, and conventional treated with selective (“soft”) pesticides.

Our work has 3 objectives:

1. What are the common predator species in potato fields?
2. Are predator densities higher in fields under organic management?
3. Do predator densities increase in conventional fields treated with soft pesticides?

During the summers of 2001 and 2002 we sampled the generalist predator community from production potato fields located throughout the Columbia Basin. In 2001 we sampled predators from 8 conventional fields – 5 treated with hard pesticides, and 3 treated with soft pesticides – and also from 3 organic fields. In 2002 we sampled predators from 15 potato fields, 5 under each type of pest management. In both years, the most common predators in the canopy were damsel and big-eyed bugs and a diverse group of spiders. On the ground surface, ground and rove beetles, and the web-building dwarf spiders, were most abundant. Predator densities were 5X to 10X higher in organic fields than in conventional fields treated with hard pesticides. Predator densities in conventional fields treated with soft pesticides were higher than in conventional fields treated with hard pesticides, but still lower than in organic fields.

We also conducted field experiments to test whether predators at densities typical of hard, soft, and organic fields would be able to suppress two common potato pests, the green peach aphid and the Colorado potato beetle. In large field cages, we manipulated the predator community to yield predator densities typical of hard, soft, and organic fields. Predators at densities typical of organic fields were effective at controlling both beetles and aphids, as were predators at densities typical of conventional soft fields. Predators at densities typical of conventional hard fields could not control either pest. Our cage experiments suggest that there are enough predators in organic fields to significantly suppress potato pests. By switching to selective pesticides, conventional growers can also take advantage of the natural control that these predators provide.

In conclusion, organic and conventional fields treated with soft pesticides contain a diverse group of predators, but predators are relatively rare in conventional fields treated with broad-spectrum pesticides. When broad-spectrum pesticides are avoided, predatory insects and spiders can reach high enough densities to control aphids and potato beetles, two important pests of potatoes.

Improved Management and Sampling of Garden Symphylans (*Scutigerella immaculata* Newport)

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Garden symphylans (*Scutigerella immaculata* Newport) are a key species in the predominantly phytophagous Symphyla family Scutigerellidae. *S. immaculata* have been economic pests of the roots and other below-ground plant parts in western Oregon and Washington since the mid-1900s. Sampling for *S. immaculata* can be difficult, and their omnivorous habits (100 hosts in Oregon) confound management.

The focus of our work was to improve *S. immaculata* management through 1) further development of the bait sampling method, 2) examination of the susceptibility of selected crops to *S. immaculata* feeding and 3) investigation of the effect of food sources on *S. immaculata* population development in the field and laboratory.

Sample size requirements were developed for the bait sampling method, and this method was compared to the standard soil sampling method. The susceptibility of selected crops to *S. immaculata* feeding was investigated in the field, laboratory and in reanalysis of previously published results. The suitability of different crops and soil alone for *S. immaculata* population development was also investigated in the field and laboratory.

Estimating densities of 1 to 20 *S. immaculata* at fixed precision levels required 1.5 times greater sample units for the baiting method than the soil method. Sampling recommendations for the baiting method performed well when validated by resampling a large independent data set. Susceptibility to *S. immaculata* feeding varied among selected crops in the laboratory and in the field. In the laboratory, as *S. immaculata* densities increased, dry weight of spinach (*Spinacia oleracea* L.) and tomato (*Lycopersicon esculentum* L.) seedlings were significantly reduced from 85 to 89%, whereas corn (*Zea mays* L.) and potato (*Solanum tuberosum* L.) dry weight were not reduced. As *S. immaculata* densities increased in the field, the normalized difference vegetation index (NDVI) of squash (*Cucurbita pepo* L.) and broccoli (*Brassica oleracea* L.) crops sharply decreased, while the NDVI of corn and potato crops was only slightly reduced. In reanalysis of previously published data, the stand counts of crops seeded into *S. immaculata* infested soil appeared to increase with seed size. In the laboratory, population growth was significantly greater on spinach than on tomato, sweet corn, potato or soil alone, and significantly lower on potato than on spinach, corn, tomato or soil alone. In the field, greater population decreases were observed in potatoes than in sweet corn or clean fallow.

The bait sampling method provides an efficient reliable alternative to the standard soil sampling method. Our findings concerning relative susceptibility of crops to *S. immaculata* feeding can be used to help develop action thresholds and sample size requirements, and reduce *S. immaculata* damage by avoiding planting highly susceptible crops in *S. immaculata* infested soil. We feel that our results provide strong evidence that crop rotation may significantly influence *S. immaculata* population levels.

IRRIGATION MANAGEMENT

Quincy Irrigation Trial: Impacting Fruit Quality with Water Management

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This trial was initiated to evaluate the effects of partial rootzone drying on tree health and fruit quality. While this trial is not completed there have been additional questions raised about irrigation, mulches, plant nutrition, fruit color, plant stress and packout impacts.

There has been such a noticeable impact on nutritional status of the trees through water management that some participants enjoy creating a debate whether this trial is about water management or nutrition.

MANAGEMENT AND MARKETING

Emergy Analysis of Food Production at S&S Homestead Farm

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To "farm in nature's image" is a primary goal guiding many contemporary efforts to develop ecologically sustainable agricultural systems. However, measuring the sustainability of agricultural systems by the criterion of how closely their function resembles natural systems is a relatively new area of research. The analysis presented here addresses this issue by quantitatively assessing the ecological sustainability of a small family farm on Lopez Island in Washington State, using a methodological framework that has origins in ecosystem science.

The objective of this study was to assess the ecological sustainability of the S&S Homestead Farm, and its individual production systems, using emergy analysis (Odum, 1996. *Environmental Accounting: EMERGY and Environmental Decision Making*. John Wiley & Sons, New York.). Emergy is defined as the available energy of one kind previously used up directly and indirectly to make a service or product, quantified in solar emergy joules (sej). The ecological sustainability of individual production systems and the farm as a whole was assessed based on a) the emergy yield of the production systems, b) the overall load the production systems place on the local environment, and c) the thermodynamic efficiency of the production systems.

The methodology used to perform the analysis of food production at S&S Homestead Farm followed the format given by Odum (1996): i) The system boundary was defined spatially as the area of land utilized for production. The temporal dimension of the study was one calendar year. ii) All major energy sources and material resources flowing into, and stored within, the farm system were identified, and the quantities were converted into energy units (Joules), mass units (grams) or monetary units (US Dollars). iii) The resource flows were measured directly, or estimated from production records. To derive emergy values, the quantities were multiplied by appropriate energy transformation ratios chosen from the literature, given in units of solar emergy joules per Joule (sej/J). iv) The products generated by the farm system were converted into energy units (Joules) using standard conversion factors from the USDA Nutrient Data Laboratory.

The analysis indicates that the various subsystems on the farm display widely differing levels of ecological sustainability. Specifically, vegetable, fruit and pork production required large amounts of imported resources in relation to the amount of locally available emergy that the systems received from the environment. In contrast beef, lamb, and grain production relied to a much larger extent on locally available emergy sources, and demonstrated higher levels of energy transformation efficiency (given as sej/J) indicating higher overall sustainability.

While the farm exhibits relatively high levels of overall ecological sustainability as currently organized, the study highlighted the fact that altering management practices in the less sustainable portions of the farm system so that they rely to a greater extent on the self-organizing ability of ecosystems and less on inputs from human labor and the economy would improve the sustainability of these subsystems.

Export of Organic Food Products to the European Union: Significance and Barriers

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Organic agricultural products are within the top twenty agricultural commodities produced in Washington State. Sales of organic food products exceeded 150 million dollars in 2001 with an average annual growth rate of 24% over the last 5 years. One-third of all apples and one half of all pears exported to the European Union (EU) from Washington State are organic.

In August 2002, access to the European market was threatened when government bodies in the EU responsible for authorizing organic imports, began revoking authorizations due to a perceived inability for U.S. certifiers to continue to attest to foreign standards under the USDA's National Organic Program. Although the WSDA Organic Program's ISO Guide 65 accreditation does, in fact, allow for certification to foreign standards, it was recognized that a more comprehensive export program and a better understanding of the EU market's role to Washington organic growers was needed.

This project served to collect the necessary data to both identify the significance of the European market to Washington State organic producers and to clarify the necessity of an international inspection program. Areas where the USDA National Organic Program differed from EU regulations were identified to enable an understanding of how farming practices must be modified to comply with EU regulations.

In order to obtain a comprehensive list of exporting producers, export documentation required by the EU was reviewed and a list of exporting companies was generated and sorted. To identify EU requirements pertinent to farmers' maintaining access to the EU market, a comparative analysis of WSDA standards, the National Organic Program, EU Regulation 2092/91, IFOAM standards, and Soil Association standards were conducted.

The European Union is a significant market for organic food products grown in Washington State. Sixteen percent of the certified organic farming operations have exported products in 2002. Produce from 18% of all certified organic acreage is likely to be exported to the European Union. The European market is essential to certain counties in particular. For example, 39% of all organic farms in Chelan County exported products in 2002.

In addition to meeting the National Organic Program requirements, organic producers must also comply with European Union regulations in order to maintain access to the market. As well as the additional paperwork that must accompany each shipment of organic products, production methods must also accommodate more rigorous requirements in the areas of GMOs, approved material inputs, and compost requirements.

The export market plays a significant role to the organic industry in Washington State. In order for Washington State Department of Agriculture to adequately address the needs of all organic food producers, a program that will inspect and certify to the European standards is necessary. Further research is needed to identify approved practices and material inputs that both comply with the EU regulations and that are economically feasible to organic producers.

“Horsepower Organics” is Horse Powered Organic Agriculture

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Horsepower Organics is a 155 acre farm in eastern Oregon which has been certified Organic with Oregon Tilth since 1993. David and Deborah Mader use draft horses as our primary power source, as a renewable cash crop and as a source of fertilizer. We also grow cash field crops on our irrigated farm.

By using horses to power our farming operation it is possible to grow field crops as well as train horses for sale and provide excellent organic/horse based internships. The considerable distance to market and the challenges of weather (from –20 degrees F to 100 degrees F) make it necessary to grow organic crops that are not perishable and can handle our climate with flood or sprinkler irrigation.

David and Deborah Mader at Horsepower Organics have a breeding operation for registered Belgian draft horses. The herd of 45 Belgians includes young horses as well as a stallion and fifteen breeding age mares. We train teams for sale by doing farm work year round with horses-in-training. David or Deborah start horses during the winter as feed teams in our deep snow country. In spring and summer Horsepower Organics provides internships for individuals interested in organic farming and becoming competent teamsters. For the past five years we have provided internships for two interns who commit to an eight to sixteen week program of training. The crops on our farm, which uses gravity fed irrigation, are alfalfa (for hay and leaf herb), barley for grain and oats for hay in rotation on the alfalfa fields. Some of the farm is in pasture as well as some pine timber and wildlife habitat. Harrowing, cultivating, mowing hay, raking hay, drilling (planting) seed, moving irrigation pipes, picking rocks, fixing fence, hauling firewood and feeding in the winter with wagon and bobsled are all done with horses. Cultivating and drilling are done with hitches of four to six horses. Summer fallow cultivation provides lots of training time for horses and practice for interns.

The result of organic farming with draft horses provides us with an income stream from both land products as well as the sale of teams of horses. The horses provide a renewable source (ten to twelve foals born per year) for much of our needed power on the farm and fertilizer from forty five horses spread out over the fields and pastures. Through our horse sales and internships we have started and maintain a network of interested people all over the Northwest. We are able to grow all of our own horse feed so have great nutrient recycling. We also make some of the highest quality alfalfa into alfalfa leaf for herb for human consumption (up to 7000 lbs yearly) and as an ingredient in organic parrot pellets.

Our ongoing organic farming project at 3000 feet in Eastern Oregon provides field crops and uses draft horses closes the loop of nutrient recycling. We use horse sales and quality internships to establish and improve farm to community relationships.

Who Cares About Biological Farming Practices?

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In the last five years, findings from several major research projects strongly suggest that a growing number of consumers support biological farming practices. To tap into this growing market segment, The Food Alliance (TFA) has created a program that, when fully implemented, allows farmers to credibly label their products with claims of verifiable biological farming practices. During the program's five-year history, a number of positive impacts are apparent including: increased adoption of biological farming practices; small market premiums; and access to markets through new business relationships.

The Food Alliance is a non-profit organization whose mission is to promote sustainable agriculture by recognizing and rewarding farmers and ranchers who produce food in environmentally and socially responsible ways, and by educating consumers and others in the food system about the benefits of sustainable agriculture.

Making the mission real:

1. In 1995, TFA contracted the Hartman Group (a nationally recognized leader in the field of consumer research) to assess the consumer marketplace for foods produced using biological farming practices.
2. Starting in 1997, TFA developed standards to evaluate and measure the extent to which farms use biological farming practices. Farms that meet TFA standards are given marketing tools and support that assist them to communicate their use of biological farming practices to consumers.
3. TFA tracks:
 - a. Increased usage of biological practices.
 - b. The incidence of market premiums associated with the Program.
 - c. The degree to which new business relationships have been developed as a result of the TFA Program.

Results:

1. The Hartman Group research indicated a significant and growing market share for biological farming practices, and identified 6 consumer profiles with common attitudes, perceptions and motivations.
2. Benefits:
 - a. A significant percentage of farms and ranches have made positive changes in management practices as a direct result of their participation in The Food Alliance program.
 - b. Participants have experienced economic benefits from participation including: small price premiums; increased sales volumes, new customers, and customer retention.
3. Increase in participation: 40% increase in the number of certified farms and ranches from 2000 to 2002.

In conclusion, TFA's initial research and ongoing work confirms that a strong and growing consumer market supporting biological farming practices exists. In addition, by participating in the Food Alliance program, a significant number of Program participants have garnered economic and other benefits (e.g. positive PR etc.). The Food Alliance's experience in the Northwest and other parts of the country provides strong evidence that both consumers and producers alike care about biological farming practices.

Insurance Coverage for Organically Grown Insurable Crops

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The Agricultural Risk Protection Act of 2000 (ARPA) provided legislation for organic farming practices to be recognized as “good farming practices.” Therefore, USDA set guidelines to provide crop insurance for organic farming practices. Prior to this ruling, crop insurance policies may not have covered production losses when organic insect, disease, and/or weed control measures were used and such measures were not effective.

The Risk Management Agency (RMA) is working to make the farming community aware of the availability of crop insurance for organically grown crops, in counties where those crops are currently covered by USDA Federal Crop Insurance Corporation (FCIC) Multiple Peril Crop Insurance (MPCI) policies. Under the MPCI, USDA subsidizes a portion of the insurance premium. RMA is striving to expand the knowledge of the availability of this USDA’s MPCI program for organically grown crops by utilizing and distributing press releases and fact sheets, making oral presentations and through direct contact with Pacific Northwest growers.

Coverage for organic acreage will be available for both transitional and certified organic acreage in accordance with approved underwriting guidelines and procedures. Insurable damage caused by insects, disease or weeds will be covered if recognized organic farming practices fail to provide an effective control. Damage caused by the failure of organic farming practices to control weeds due to an insured cause of loss is also covered. If any acreage does not qualify as a certified organic acreage or transitional acreage location within the unit by the final acreage reporting date, such acreage will be insured under the provisions of the standard policy and applicable rates and coverages for the conventional practice or type in effect on the final acreage reporting date.

FCIC is currently revising the Basic Provisions to reflect the modifications made by ARPA. Until specific insurance program procedures are set in place, USDA’s RMA will recognize organic farming practices as good farming practices by providing coverage for organic producers by written agreement. Written agreements are not available for catastrophic risk, income protection, revenue assurance plans of coverage or for pilot program crops, unless permitted by the crop provision.

Producers may contact the Spokane Regional Office at (509)353-2147 or consult their crop insurance agent to obtain specific information and applicable deadlines. A list of crop insurance agents is available at all USDA Service Centers throughout the U.S. or at the RMA website address: www.rma.usda.gov/tools/agents/

SOIL BIOLOGY

Orchard Floor Management Practices for Improving Soil Quality and Optimizing N Uptake Efficiency

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Alternative orchard floor management systems (AOFMS) were a primary concern of orchardists especially with respect to the role they may play in soil fertility, control of erosion and compaction, surface runoff of pesticides, and pest management. In response to a number of workshops where soil ecology and orchard floor management was discussed, orchardists also began to ask the question- in what ways could we manipulate the soil ecology to optimize the use of fertilizers? Based on these concerns, grower input, and a review of the current practices in annual and perennial cropping systems, we are evaluating soil quality; N uptake, utilization and distribution; mycorrhizal association; and root distribution in a range of AOFMS.

The goals for the research include:

1. Evaluate the effect of alternative orchard floor management systems (AOFMS) on soil quality with emphasis on soil biological characteristics, mycorrhizal associations and root distribution.
2. Determine if the AOFMS can improve the uptake efficiency of fertilizer N, its distribution and recycling within the tree.
3. Ascertain the effect of AOFMS on vole and weed pests.
4. Evaluate yield, tree growth and fruit quality.
5. Perform crop profitability analyses for different AOFMS's.

Field studies began in spring 2001. Baseline physical and chemical soil quality data were obtained from two experiment station research plots: Lewis-Brown (8-yr old 'Fuji' apple trees) and Hood River (3-yr old 'Red Delicious'). The research plots are arranged in a randomized complete block, split-plot design. The main plot effects are cultivation or herbicide. The sub-plot effects are the tree row amendments, which were applied in spring 2001 and included: 1) no amendment, 2) legume/grain hay, 3) compost, and 4) bark mulch. Enriched ^{15}N was applied to single-tree replicates in spring 2001, 2002 and will be applied in 2003. Above-ground dependent variables are yield, TCSA, leaf and fruit N and ^{15}N concentration. Below-ground and soil dependent variables include active fungal and bacterial biomass, protozoa and nematodes, soil respiration, physical soil characteristics and root N and ^{15}N concentration. Root distribution and mycorrhizal association studies have begun. After the 2003 growing season, trees will be excavated, partitioned into components, dried, sub-sampled, and analyzed for N and ^{15}N . N distribution and uptake efficiency will be determined.

Data collection and analysis of dependent variables has just begun. AOFMS appears to be influencing the active fungal:bacterial ratio. Weeds were reduced significantly in the uncultivated mulched rows. TCSA was increased in the young 'Red Delicious' trees treated with compost. In the autumn of 2002, respiration rates were the highest in compost amended tree rows, mulch and legume/grain treatments were intermediate, while non-amended rows had the lowest respiration rates.

Soil Enzyme Activity as a Sensitive Indicator of Ecosystem Disturbance

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Ecological assessment of ecosystems is a priority in order to assist land managers and policy makers to promote long-term sustainability, yet quantifying environmental sustainability remains an elusive goal. One approach is to use the soil as an indicator of ecosystem 'health'. Soil enzyme activity assays are advantageous as a potential indicator because they are: operationally practical; sensitive integrative 'biological fingerprints' of past soil management; and apparently related to soil aggregation, linking enzymes with soil tilth. Consequently, we initiated a study of enzyme assays in combination with other microbial, physical and chemical properties on a wide range of Oregon forest and agricultural soils under diverse management/disturbance systems.

Our objectives were to determine: (1) temporal dynamics and sensitivity of selected soil enzyme activities to soil management in diverse soils and ecosystems; and (2) to develop conceptual models on the role of enzyme activity as an indicator of soil quality.

In 1999 and 2000 the following Oregon sites in humid and semiarid environments were sampled up to 3 times from spring to fall: 6 forested experimental sites with paired comparisons of old growth timber (>100 yr stand) vs. clear cut (< 8 yr stand); and 2 long-term agricultural experiments (RCB design) and 7 paired comparisons in farmers fields with C rich/low disturbance vs. conventional systems. Soil cores (0 to 15 cm depth in agricultural soils) (A horizon in forest soils) were bulked for each replication. Three enzyme assays (β -glucosidase, arylsulfatase, and FDA hydrolysis) were studied because the assays are simple (i.e. potential for commercial adoption) and have shown consistent sensitivity to treatments (Miller and Dick, 1995; Bandick and Dick, 1997). Soils were characterized for physical properties as well as microbial biomass C; CO₂ respiration; DOC; active/dead fungal and bacterial biomass by direct counts; ergosterol as fungal indicator; *q*CO₂; and wet aggregate stability.

Forest soils generally had much higher activities than agricultural soils. There was a very consistent pattern in the agricultural soils in that those receiving greater C inputs (as cover cropping, manure, and green manure) have higher activities than the plots receiving lower C inputs. In agricultural soils the biological measurements ergosterol, fungi biomass, and biomass C were highly correlated with soil enzyme activities. However, bacterial counts show very few significant differences as a function of soil management in either forest or agricultural soils. Arylsulfatase showed good correlation with fungal biomass and ergosterol (a fungal marker). This is a promising finding, linking this enzyme to fungi which are important in affecting the quality of soil. The results showed that soil enzyme activities are related to the soil biological component. Arylsulfatase and β -glucosidase activities were best at showing treatment effects and had more temporal stability than other microbial measurements, indicating these may be good indexes of soil quality trajectory for a given soil management system.

Earthworm Populations and Species in the Palouse of Eastern Washington

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Farmers, gardeners, and ecologists view earthworms as beneficial soil organisms indicative of healthy soils. In the higher rainfall areas of Washington, earthworms are normally abundant and are expected to be part of the ecosystem. However, in the drier Palouse region of eastern Washington and northern Idaho, earthworm populations and dynamics have not been well documented. Since the early 1900s, most of the Palouse had been converted to dryland farming except for intermittent streams and areas too rocky to till. We surveyed 46 sites in spring 1999 to determine the occurrence and distribution of earthworm species within the agricultural landscape. Although species diversity in the agricultural fields was low, three species are reported in the survey area for the first time. No native earthworms were found. Ten alien lumbricid species were found. The most common, *Aporrectodea trapezoides*, was found at 65% of all sites. Of the farmed field sites, 61% contained one or more species. This preliminary survey provides the baseline knowledge necessary to design future studies on earthworms.

Cover Cropping and Soil Microbial Community Ecology in Western Oregon

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Microbial community responses to alternative management may be indicative of soil quality change. To better understand shifts in community structure, we characterized microbial communities from six commercial vegetable grower fields over the course of one growing season. The growers split their field into two systems, an alternative management practice that consisted of winter cover cropping or reduced tillage treatments, which was compared to conventional tillage and winter fallowing. Soil samples (0-15 cm) were taken from each treatment three times during the growing season of 1998. Microbial fatty acids were extracted from soil and methylated to form fatty acid methyl esters (FAMES) using the ester-linked method (Schutter and Dick, 2000) and analyzed by multivariate analysis with principal components (PCA) and canonical discriminant analysis. FAMES can be biomarkers for certain microbial species or functional groups in soils. Correlations between soil properties and PC scores or FAME concentrations were calculated. Biomass C and soil enzyme activities for grower field soils were obtained from Ndiaye et al. (2000). Within a season, community FAME profiles often were correlated with several soil properties, including texture and C content. Concentration of individual FAMES also was correlated with soil properties. This may help to identify FAMES, which are indicators of soil quality. For example, *i16:1 G* was strongly correlated with microbial biomass C, enzyme activity, and total C, but the origin and nature of this FAME is not well known. Microbial communities did shift in response to cover crop residues and often contained elevated amounts of fungal and protozoan FAMES. However, the treatment effect generally was observed only when fields were analyzed individually. Canonical discriminant analysis separated communities from grower field soils according to cover crop treatment. Canonical functions may be a useful for predicting changes in soil quality as microbial communities shift in response to alternative management systems.

VARIETY DEVELOPMENT AND TESTING

Dry Bean Varieties for Niche Markets in the U.S.A.

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Washington State University is a major participant in the Bean/Cowpea Collaborative Research Support Program (B/C CRSP) and has been the lead institution on the B/C CRSP in Tanzania, East Africa. The B/C CRSP was established in 1980 by the United States Agency for International Development (USAID) with the primary objective of increasing the availability and utilization of high quality dry beans and cowpeas worldwide. Dry beans are the second most important source of dietary protein in the world, have anti-cancer attributes, and play an extremely important role in human health, nutrition, and well-being. The B/C CRSP is a unique USAID project in that research is conducted to directly benefit developing countries and the United States. Much is known in the United States about large-scale bean production for commodity markets, but little information is available regarding small-scale production and niche-market bean varieties that are suitable for production in western Washington.

The objectives of our work are to: 1) test the production of niche market dry beans in western Washington; 2) survey dry bean producers throughout the state to determine scales of production, prominent varieties, and major production problems in the different regions; and 3) develop publications that highlight variety characteristics, seed quality issues, and dry bean production in the Pacific Northwest.

Replicated field trials were conducted in 2001 and 2002 at Vancouver REU. More than 70 dry bean varieties were planted each year and most reached maturity. Disease problems included halo blight, sclerotinia and several legume viruses. Based on our results, we have posted a webpage that includes photographs of 50 bean varieties and their characteristics including plant height, seed color and shape, and days to maturity, <http://eastafriacrsp.wsu.edu/beans/beanVarieties.html>.

In the spring of 2002, we distributed a survey questionnaire to 124 dry bean farmers across the state and were successful in interviewing 46 farmers. Two thirds of the respondents were located on the west side of the state and one third were located on the east side. In the Columbia Basin, all farms were large-scale (hundreds of acres) and all respondents were male. In the western region, all farms were small-scale (maximum 1 ¼ acres) and the majority of respondents were female. The respondents grew a total of 69 different dry bean varieties and felt the major production problems that needed to be addressed were weed and disease control, poor germination, poor flowering, late maturity in western Washington, and lack of suitable small-scale threshing equipment. Respondents indicated that on-farm storage of dry beans posed no problems to bean quality. All large-scale respondents grew seed on contract for companies that handled all the marketing, and most small-scale respondents grew dry beans mainly for their own consumption and marketed their beans through farmers' markets and farm stands.

In our field trials in Vancouver we have identified early maturing varieties that are suitable for production in western Washington. Some varieties appear to be better suited to mechanical harvest while others are more attractively colored and patterned and may be well suited to fresh market. Future research at Vancouver will include production systems that reduce pesticide usage for weed and disease control, and the development of small-scale threshing and cleaning equipment.

The Need for Organic Plant Breeding Programs, with Wheat as an Example

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"Currently, organic farmers largely depend on varieties supplied by conventional plant breeders, even though organic farming conditions demand varieties with different characteristics than conventional varieties. Despite these (conventionally bred) varieties' higher yield compared to old varieties – on organic farms, too – performance in organic systems could be vastly improved if varieties were bred for typical organic conditions." Louis Bolk Institute, Sustainable organic plant breeding

For the past 50 +/- years, our food crops have been bred under conditions of high chemical inputs, from artificial fertilizers capable of carrying the plant through to maturity to fungicides and pesticides which render breeding for disease and pest resistance significantly less important. For conventional farmers, these high-input, genetically uniform varieties are essential to the success of their mode of production. For organic farmers, these varieties are often our best and/or only choice for production; however, many traits important to the organic community are diminished or are missing entirely.

Variation exists in abundance within the gene pool for a number of traits that may be useful under organic production. These traits may be highly adaptive under organic farming conditions while at the same time be considered unimportant in high chemical input systems and therefore ignored and/or overlooked within conventional breeding programs. For example, if breeding foundation seeds are routinely treated with a fungicide before planting, how are we to breed for resistance to the fungus *Pythium*, which causes damping off? Cultural traits such as aggressive spring harrowing in winter wheat must be addressed as well, and varieties that thrive under organic systems become the cornerstone of organic plant breeding programs.

Between 1840 and 1955, at least 163 distinct varieties of wheat were grown in the Pacific Northwest. All of these were grown and selected under organic conditions and exhibit various degrees of genetic elasticity. Though none of these varieties on their own could compete today with our modern elite varieties, they each potentially possess valuable traits which could significantly enhance the modern varieties contributing resilience both to perform well in many different environments and to adapt to different localized conditions.

In the WSU Organic Wheat Breeding Program, we are growing each of the 163 wheat varieties mentioned above and evaluating them for traits beneficial to organic farming. In addition we are crossing these historical wheats to our modern varieties and evaluating the subsequent generations. We work closely with farmer / cooperators both for variety testing and input on useful traits. We place utmost importance on breeding wheat on certified organic farms under the same conditions and systems practiced by the farmer. All research must be designed to benefit the farmer and the public and all varieties kept in the public domain.

Development of Open-Pollinated Broccoli Varieties for Local Cropping Systems

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An improved open-pollinated (OP) broccoli cultivar is needed for home garden and fresh market growers in the Pacific Northwest because most existing OPs are inferior in many respects compared to contemporary hybrids. It should be possible to develop an OP cultivar that has better quality than existing hybrids and as good horticultural productivity. The OSU Vegetable Breeding Program has been developing improved broccoli types for processing and mechanized harvest. In 1997 six commercially available F₁ hybrids and 17 OSU inbreds were random-mated in an isolation nursery and a representative sample of seed was harvested from each plant. In subsequent years, types with acceptable head quality were selected and again allowed to random-mate. Four such cycles of mass selection were completed. The population has genetic variation for head shape and size, exertion and head height, segmentation, bead size, branching, color maturity, club root resistance, and downy mildew resistance. In the spring of 2002 seed of this population was given to the Farmers Cooperative Genome Project for distribution to cooperating growers for production and selection in their particular cropping system.

The objective of this project is to develop broadly adapted open-pollinated broccoli cultivars for the Pacific Northwest. A secondary objective is to engage growers in a participatory plant-breeding process.

The project is in preliminary stages of implementation. A set of common breeding objectives has been identified. These include: 1) Vigorous, healthy growth under organic growing conditions, competitiveness with weeds, and resistance to any pests or pathogens that are present. 2) Medium size nonsegmented heads (2-3 inches in diameter) with tight, refined beads. (Heads should be of size and shape that can be attractively bunched in groups of three.) 3) Clean leaf abscission so that leaves can be stripped in the field without using trimming knives. Guidelines for planting include keeping plants in regularly spaced blocks to maintain interplant competition, keeping at least 100 plants to prevent inbreeding, and keeping other *Brassica oleracea* crops (Brussels sprouts, cabbage, kohlrabi, kale, collards, cauliflower) from flowering within 1500 feet of the production site.

Three growers, who targeted the crop for fall production, planted seed. As such, these populations have not produced mature seed. Plants will be cut back and overwintered to obtain seed production in the early spring. If fall planting evaluation and spring seed production is not successful because of winterkill, we will plant in early spring (late April is preferred) with selection during May and seed harvested in September.

A composite from each site of approximately 400 seeds is to be returned to FGCP for mixing and redistribution for another round of selection. Several cycles of selection in this fashion should result in adaptation to a broad range of growing conditions. Individual growers may want to derive their own locally adapted OP broccoli cultivar from this source material.

Lingonberry Variety Trial

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Lingonberries were introduced to Oregon in 1991 by a local nursery. Since that time, growers in the Pacific Northwest have been asking the question, “Will lingonberries grow in the Pacific Northwest?” Since there weren’t any being grown commercially in 1991 many questions could not be answered. A research project was begun to look at lingonberries and see if they would successfully grow in Oregon and Washington.

We conducted collaborative on-farm testing of 16 different lingonberry varieties. We looked at total yield, individual berry weight, and brix. Information was also collected on plant characteristics and habits.

The testing of lingonberries was conducted on 13 farms in Oregon and 3 farms in Washington. The plots were planted between 1996 and 1998. The lingonberries are picked the first week in August and the first week in November, taking advantage of its double cropping potential. Additional information has been collected about the plant characteristic, growth habit, weed resistance, planting space, insect and disease problems, and bloom period.

The on-farm data have been collected for four years. The data represent summer, fall and combined information. The summer brix values show that berries range from 5 to 12 brix with 5 varieties in the 12 brix range. The fall brix show a range of 9 to 16 brix with 4 varieties in the 15 brix range.

For fruit yield, both summer and fall yield data were gathered. Koralle-G and Ernte sagen showed average yields over 900 kg/100m². Individual berry weights showed a range of berries from 0.15 grams to 0.57 grams. Ida and Ernte sagen having the largest individual berry weights.

Data were compared from the summer and fall pickings. Data from the on-farm trials show that lingonberries have the potential to be grown in Oregon and Washington and have sufficient yield to compete with other berries. There are currently over 23 acres of lingonberries being grown commercially in the two states with weekly calls coming from around the United States and Canada asking how to grow this new crop. The on-farm data illustrate the differences between the 16 varieties, summer and fall crop yields and berry size. This information will help nurseries determine which varieties to propagate.

The Farmer Cooperative Genome Project

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The Farmer Cooperator Genome Project (FCGP) introduces gardeners and farmers to the practices of plant evaluation, seed regeneration, and plant variety development. Participants work with publicly bred varieties and public researchers from the Vegetable Breeders Institute at Cornell University and the USDA National Plant Germplasm System (NPGS).

The FCGP seeks to increase grower access to plant genetic resources, support grower evaluation efforts, and improve grower capacity to breed plants and grow seed. FCGP participants conserve plant genetic resources, introduce new varieties for organic growing conditions, and develop innovative marketing systems for seed producers.

Cornell varieties are grown in randomized replicated plots and compared with standard varieties. FCGP participants evaluate NPGS plant varieties using descriptor and plant evaluation forms. Photographs are keyed to color charts with metric size references. Participants use traditional breeding techniques to develop significant traits and introduce new varieties. Marketing is based on cooperative principles, using innovative outreach and distribution systems.

The primary activity of the FCGP to date has been characterization, the description of plant varieties in the NPGS. Our members volunteer to grow and evaluate varieties, providing valuable information to both the NPGS and commercial seed growers. The FCGP and NPGS are working together develop a set of crop specific descriptor forms aimed at facilitating the NPGS curator efforts by making it easier for FCGP participants to accurately characterize their plant varieties. In our work with the Cornell Vegetable Breeding Institute, the FCGP and eight participant growers are conducting replicated trials to provide quantitative data on how 12 different Cornell varieties perform under organic conditions across Oregon. Varieties evaluated include an OP charentais type cantaloupe, two virus resistant hybrid melons, a powdery mildew resistant OP Iroquois melon, powdery mildew resistant squash (pumpkin, green and striped zucchini, yellow straightneck and acorn squash), Marketmore and Poinsett type slicing cucumbers with bacterial wilt resistance, and blight resistant tomatoes. The FCGP is also working with Jim Myers from the Horticulture Department at OSU to breed an OP, organic broccoli variety for commercial use in the Pacific Northwest. FCGP participants are selecting from a hardy population variable for color, head shape and size, maturity, height, stalk exertion, and more.

Since 1998 the FCGP has distributed over 1250 different plant varieties from the USDA seed banks. Evaluations were returned for 187 of those varieties. NPGS varieties are widely variable, including very heterogenous types and stable lines. Marketable varieties found include salad leaf broccoli and reverse ribbed pumpkins. The FCGP currently has 68 varieties of seed grown by participants available for redistribution, from amaranth to zucchini. The Cornell variety trial results include powdery mildew resistance in squash and cucumbers, and blight resistant tomatoes. Broccoli trials with OSU are yielding OP, stress resistant, marketable heads. Workshops throughout Oregon demonstrated plant evaluation procedures, seed-saving methods, and traditional breeding techniques.

AUTHOR INDEX

Always, Ted.....	18, 19	Knight, T.	35
Andrews, Preston K.	7	Koopmans, C.J.	5
Auvil, Tom	28	Koss, Amanda M.	26
Azarenko, Anita Nina	34	Lacey, L. A.	22, 23
Bary, Andy	1, 4, 6, 24	Lammer, Doug	39
Beaver, Theresa	16	MacConnell, Craig	6
Becker, K.	22	Mader, David	31
Bezdicek, David	36	Mader, Deborah.....	31
Boches, Peter	40	Mahaffee, Walt	15
Book, Brenda	30	Mazzola, Mark	12
Bristow, Peter R.	9	McGuire, Andy	13
Carkner, T.	24	Miles, Carol A.	9, 24, 38
Carpenter-Boggs, Lynne	2	Moscattello, Jonathan	32
Chozinski, Annie	34	Muehleisen, D. P.	24
Cogger, Craig	1, 4, 6, 24	Mullinix, M. Kent.....	11, 12
Coyne, Daniel	6	Murphy, Kevin	39
Darby, Heather	3	Murray-Armstrong, Cindy	17
Dick, Richard P.	3, 35, 37	Murray, Tim	39
Dreves, Amy J.	20	Murray, Todd	6
Elfving, Don C.	12	Myers, Jim	40
Fauci, Mary	36	Nicholson, Martin	9, 24
Finger, Sarah	34	Ostrom, M. R.	24
Fisher, James R.	27	Pascoe, N.	35
Forge, Tom	34	Peck, Gregory M.	7
Gale, Eric	4	Penhallegon, Ross H.	14, 41
Glover, Jerry D.	7	Pfannenstiel, R.	22
Gonzalves, Pete	42	Pinkerton, John N.	9
Gundersen, Babette	10	Prasad, Renée Priya	25
Granatstein, David M.....	11, 12, 17	Reeve, Jennifer	2
Haapala, J.J.	40, 42	Reganold, John P.	2, 7
Haden, Andrew C.	29	Righetti, Tim	34
Headrick, H.	22, 23	Rugel, Darla	8
Heeres, E.	5	Sandeno, J.	35
Hemphill, Del	4	Scheuerell, Steve	15
Henderson, Deborah E.	25	Schowalter, Shannon	20
Hinman, Herbert R.	7	Schutter, Mary	37
Hoffmann, D.	22	Seiter, Stefan	34
Hogue, E.	11	Seufer, Jo Lynne	33
Horton, David	21	Siplak, Rebecca	32
Inglis, Debra Ann	10	Smith, Heather	42
Jamison, Rachael	30	Snyder, William E.	25, 26
Johnson, A.	24	Sonde, Madhu	38
Jones, Stephen	39	Stone, Alex	3, 20

Sullivan, Dan	1, 4	Vail, P.	22
Taylor, A.	35	Voogt, W.	5
Tonks, Dennis	8	Wagner, J. R.	35
Umble, Jon R.	27	Wander, Michelle	3
Unruh, T. R.	22, 23	Williams, Cinda	16
Upton, J.	23		

Washington State University

CENTER FOR SUSTAINING AGRICULTURE AND NATURAL RESOURCES

Mission

The Center for Sustaining Agriculture and Natural Resources (CSANR) works to create sustainable agriculture and natural resource systems that provide a high quality of life for the people of Washington. The CSANR leads in developing and implementing interdisciplinary systems-oriented research and education programs at Washington State University.

CSANR Activities

The CSANR is involved in a variety of programs and projects such as:

- Agricultural Systems
- Agriculture and Energy
- Biologically Intensive and Organic Agriculture
- Community Capacity Building
- SARE Professional Development Program
- Small Farms Program
- Internship Program in Sustainable Agriculture

The CSANR conducts applied research and educational events, builds partnerships and produces publications. The CSANR relies on an external advisory committee that represents a broad spectrum of interests to guide priority setting and to recognize new needs and opportunities.

CSANR Personnel

The CSANR is housed within the College of Agriculture and Home Economics and is comprised of individuals located at WSU units across the state:

Chris Feise, Director, WSU Puyallup REU
Cindy Murray-Armstrong, Assistant to Director, WSU Puyallup REU
Ed Adams, WSU Spokane
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