Center for Precision & Automated Agricultural Systems CPAAS 2012

WASHINGTON STATE UNIVERSITY

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WSU Center for Precision & Automated Agricultural Systems
Washington State University
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Message from the Director

The WSU Center for Precision and Automated Agricultural Systems (CPAAS) has continued to strive for preeminence in 2012. We are taking firm steps toward achieving our mission statement goals of:

"*Providing a venue for: (1) High impact research outcomes for our stakeholders; (2) True trans-disciplinary collaboration within WSU and World-wide; (3) High quality educational and research experiences for our students; and (4) Incubation and development of new ideas relevant in an entrepreneurial climate*".

The production of high impact research outcomes relies heavily on having an excellent faculty. We continue our effort to increase the center's impact by creating a more collaborative environment which attracts faculty to join us in pursuit of a common goal. CPAAS officially appointed 10 faculty members from Departments (Schools) of BSE, EECS, SES, HLA, MME and WSU Extension as affiliate members in 2012. This excellent faculty team conducts multiple research projects, including five multi-institutional, trans-disciplinary federal funded research projects and several industry funded projects. Based on the knowledge gained from those research projects, the CPAAS team collectively published 29 articles in different peer reviewed professional journals in addition to the numerous papers and posters presented at national and international professional conferences and industry meetings.

To promote research collaboration world-wide, we have organized and hosted an International Precision Agriculture Forum. Twenty-two internationally well-known research leaders in precision agriculture from eighteen world-ranked universities, research institutes and equipment manufacturers from seven countries participated in this forum held in Richland, WA. Initiating bilateral and multilateral collaborations was one of major outcomes from this Forum.

We have also put a great effort toward providing high quality educational and research experiences for our group, which included supporting a harmonious atmosphere for graduate students and post-doctorates of different cultural backgrounds performing challenging but rewarding learning and research. To provide our domestic students with international experiences in addition to working with international students side-by-side, we have created opportunities for them to gain direct international research experience in two of our collaborating institutes of higher education in Japan and Germany. One of our students took the opportunity in 2012 to spend several weeks studying in Japan.

To make our research outcomes useful tools for crop growers is always on top of our to-do list. In 2012, several of our faculty investigated different approaches for making technologies they developed available to society.

Working as a team, we are committed to developing a "World preeminent and Washington relevant" research and education program and to create solutions with precision agriculture and agricultural automation.

CPAAS Faculty

Qin Zhang
Professor- Biological Systems Engineering
Director– Center for Precision & Automated Agricultural Systems

Dr. Qin Zhang is the Director of CPAAS, and a Professor of the Biological Systems Engineering Department. He received his Ph.D. degree from the University of Illinois at Urbana-Champaign in 1991, his M.S. degree from the University of Idaho in 1987, and his B.S. degree from Zhejiang Agricultural University in China in 1982. Prior to his arrival at WSU, Dr. Zhang was a professor at the University of Illinois at Urbana-Champaign, and before joining the faculty at UIUC in 1997, he worked at Caterpillar Inc. as a Senior Engineer. Dr. Zhang has focused his teaching and research activities on agricultural mechanization, agriculture automation, and intelligent machinery. Based on his research outcomes, he has written two textbooks, published over 100 peer reviewed journal articles, presented over 200 papers at conferences, and has been awarded nine U.S. patents. He is currently serves as the Editor-in-Chief for *Computers and Electronics in Agriculture.*

Paul G. Carter
Associate Professor
WSU Extension and Columbia County Director

Paul G. Carter joined WSU Extension in 2005 serving the Columbia County Extension Office and WSU Extension. In 2011 he joined CPAAS as a remote sensing and dry land precision agriculture specialist working in the SE Washington area. From Purdue University, he earned his B.S. (1974) in Agriculture Mechanization, M.S. (1999) in Agronomy Soil Science, and completed a Ph.D. (2005, ABD) in Agronomy and Remote Sensing. While completing degrees at Purdue University, he worked as a staff member with the Laboratory for the Applications of Remote Sensing (LARS) and the Department of Agronomy. Paul's Extension programs in agriculture include precision technology applications, soil nutrition, and cropping systems. He participates in many of the county and state agricultural organizations including Sec/Treas of the Washington State Crop Improvement Association. Internationally, he serves on the editorial board of the Journal of Precision Agriculture and presents at regional, national and international conferences. Paul has initiated local Precision Farming seminars in Columbia County, and presented in other regional counties in Washington and Oregon. His leadership has impacted the adoption of precision technologies in the dry land wheat production area of Washington State. He is currently working with soil pH and nutrient balancing to help producers remain sustainable and vibrant.

Amit Dhingra
Associate Scientist/Associate Professor
Department of Horticulture

Amit Dhingra is a horticultural genomicist at Washington State University. His research focuses on sequencing genomes and then taking that information to produce better fruit

Karina Gallardo
Assistant Professor/ Extension Economist
WSU Wenatchee TFREC
School of Economic Sciences

Dr. R. Karina Gallardo is an Assistant Professor Extension Specialist in the School of Economic Sciences, stationed at the Tree Fruit Research and Extension Center of Washington State University in Wenatchee. She holds a BS in Food Science from the Universidad Nacional Agraria La Molina (Lima, Peru), a Master in Science in Agricultural Economics from Mississippi State University and a PhD in Agricultural Economics from Oklahoma State University. Gallardo's primary research and outreach program goal is to enhance value-added agribusiness opportunities for specialty crops in the state of Washington. As such, her areas of research are focused on consumer demand analysis and economics of technological change. More specifically, Gallardo is conducting research assessing consumers' preferences for fresh fruit quality, and understanding the profitability and various other factors affecting growers' adoption of new technologies, such as new cultivars, improved pest management systems, and labor enhancing mechanisms.

Gwen-Alyn Hoheisel
Area Extension Educator
WSU County Extension Prosser

Gwen-Alyn Hoheisel started in 2006 as a faculty member with WSU Extension working in commercial tree fruit and grapes. She received her Master's degree in entomology from Pennsylvania State University in 2002, and her B.S. degree in zoology from University of Maryland in 1998. Hoheisel has focused her work on sustainable pest management, application technologies, and the use of digital media to enhance information delivery to growers. Hoheisel also sits as an ex-officio board member to 5 Washington tree fruit and grape commodity organizations.

Manoj Karkee
Assistant Professor
Biological Systems Engineering

Dr. Manoj Karkee is an affiliated faculty member to the center and is an assistant professor in the Biological Systems Engineering Department. Dr. Karkee was born in Nepal where he received his undergraduate degree in Computer Engineering. He went to Asian Institute of Technology, Bangkok, Thailand in 2003 for his Master's Degree in Remote Sensing and GIS. He received his PhD in Agricultural Engineering and Human Computer Interaction from Iowa State university in 2009 and joined WSU in 2010. Dr. Karkee has established a strong research program in agricultural automation and mechanization area with particular emphasis on machine vision systems. Some of his sponsored projects include *crop load estimation, fruit tree pruning, plant stress monitoring,* and *solid set canopy delivery*. He has published in journals such as 'Computers and Electronics in Agriculture', and 'The Transactions of ASABE' and has been an invited speaker at several national and international conferences.

Karen Lewis
WSU Regional Tree Fruit Specialist
Grant-Adams Area Extension
Executive Board Member CPAAS

Karen Lewis is a WSU Extension Regional Tree Fruit Specialist housed in the Grant-Adams Area Extension office and CPAAS. She earned her B.S. degree in Plant Science and her M.S. degree in Horticulture at the University of Arizona. Karen's extension and applied research program has been guided by active participation and leadership in international, multi state and statewide academic teams and grower member industry organizations. Current program focus includes: development and integration of mechanized / labor assist technologies for tree fruit pruning, thinning and harvest; competitive apple and pear orchard systems; Engineering, horticultural and economic strategies for sustained production of high quality tree fruit nursery stock and light duty electric vehicles for on-farm operations. Since 2005, Lewis has secured over $1M in program support, jointly published 6 articles in horticultural and engineering journals and been an invited speaker throughout the US, Canada, New Zealand and Australia.

Changki Mo
Assistant Professor
School of Mechanical and Materials Engineering

Dr. Changki Mo is an affiliated faculty member to the center and is an assistant professor in the School of Mechanical and Materials Engineering at Washington State University-Tri-Cities. He received his Ph.D. degree in Mechanical Engineering from the University of Oklahoma in 1996. Before joining WSU, Dr. Mo was Visiting Professor in the Department of Mechanical Engineering and Materials Science at the University of Pittsburgh, Pittsburgh, PA and Associate Professor in Automotive Engineering Department at Kyungpook National University (Sangju, South Korea).
His research interest includes vehicular and structural vibration control, hydraulic control system, energy harvesting: self-powered medical implants and self-powered structural health monitoring, micro actuators and sensors, adaptive structure technology, and smart structures for sustainable buildings. Much of his current research focuses on morphing systems using shape memory polymer and piezoelectric systems for actuators, resonators, sensors, or energy sources. He has published about 50 peer reviewed journal and conference articles and one book chapter.

Troy Peters
Extension Irrigation Specialist/Associate Professor
Biological Systems Engineering

Dr. Troy Peters works for Washington State University and serves as the Extension Irrigation Specialist at the Irrigated Agriculture Research and Extension Center in Prosser, WA. Troy received his Ph.D. in irrigation engineering from Utah State University. Following graduation he worked at the USDA-Agriculture Research Service Conservation and Production Research Laboratory in Bushland, TX for three years. He has been with Washington State University for over 6 years. He is also a certified agricultural irrigation specialist and is a licensed professional agricultural engineer.

Li Tan
School of Electrical Engineering and Computer Science
WSU Tri Cities

Dr. Li Tan is an Assistant Professor in School of Electrical Engineering and Computer Science, and also on an affiliate assignment from CPAAS. He received his Ph.D. degree in Computer Science from State University of New York at Stony Brook in 2002. He also have a M.S. degree in Computer Science (1999) from State University of New York Stony Brook, a M.S. degree in Computer Science (1997) and a B.S. Degree in Physics (1992) from Fudan University in China. Prior to his arrival at WSU in 2007, Dr. Li Tan was a research engineer at Mathworks, Inc. from 2004, and before that, a research associate and Postdoctoral fellow in the University of Pennsylvania. Dr. Li Tan's research interests include software testing and verification, dynamic system modeling and analysis, logistic system modeling and analysis, and decision support for precision farming. He published more than 30 articles on journals and peer-reviewed conference proceedings. He is currently directing the Center for Experimental Software Engineering at Washington State University, TriCities.

Dr. Matthew Whiting
Associate Professor/Scientist and Extension Specialist
Department of Horticulture and Landscape Architecture
Executive Board Member CPAAS

Dr. Matthew Whiting is an Associate Professor/Scientist and Extension Specialist in the Department of Horticulture and Landscape Architecture. He received his Ph.D. degree from Washington State University in 2001, his M.S. and B.Sc. degrees from the University of Guelph in Canada in 1998 and 1996, respectively. Dr. Whiting leads the stone fruit physiology program that addresses the key horticultural and physiological issues facing the industry. Dr. Whiting's research efforts are leading the integration of mechanization and automation in tree fruit through the development of planar orchard systems that are productive, precocious, profitable, and sustainable. Since 2002, Dr. Whiting has published over 40 peer-reviewed journal articles, garnered $6M+ in grant funding, and given invited presentations around the globe.

CPAAS External Advisory Board
Keith Oliver, Richard Fenske, Gary Snyder, Scott Williams, Ruben Canales, Scott Korthius
Not shown are Walt Hough and Al Robison

Robert Dickson
Information Systems Coordinator

Robert grew up in Seattle and graduated from the University of Washington with a degree in Political Science. His passion for computer technology led him to own and operate a small business in computer retail sales and service in Kennewick, WA for a number of years. Most recently Robert worked at Pacific Northwest National Laboratory in Richland, WA supporting IT in Information Management Services. Robert has a passion for technology and loves working within the research community**.**

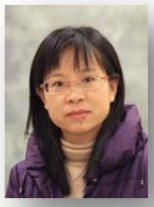
Patrick Scharf
Engineering Technician III

Patrick earned his B.S. in Animal Science from the University of Wisconsin-Madison in 1999. Scharf is currently working toward a Masters in Biological and Agricultural Engineering, here at WSU. Scharf's role at CPAAS includes management of facilities, research project management, project design consulting, project fabrication, safety coordination, shop manager, vehicle management, and providing assistance with administrative issues as they pertain to his activities. Scharf is also a coauthor on CPAAS publications and a listed contributor on invention disclosures to which he has made a significant contribution.

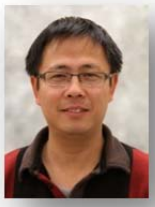
Linda Root
Finance Budget Manager

Linda came to WSU in 2006 with of seventeen years of experience in small business management. She helped facilitate the spin-off of AgWeatherNet and has been working to assist the growth of CPAAS. She has an AA degree in Business Administration from Columbia Basin College and performs functions in Center finance management, grant management, purchasing, travel, event planning as well as principal assistant to the Director.

Visiting Scholars


Yanhua Jia


Liu Gang


Aiping Xiao

Student Summer Interns


Ute Adameit

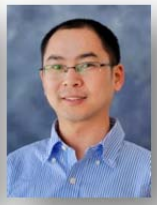

Igor Ewlanow


Afaliq Yusof


Mohd Akmal Bin Hohmad

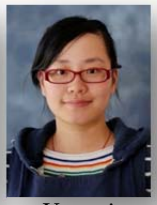
Post-Doctoral Research Associates


Yiannis Ampatzidis


Long He


Peter Ako Larbi


Shaochun Ma


Yongni Shao

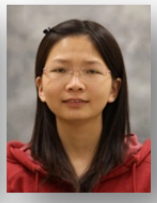

Ajay Sharda

Graduate Students

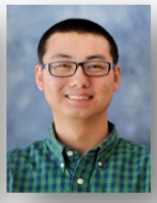

Bikram Adhikari


Suraj Amatya


Mark DeKleine

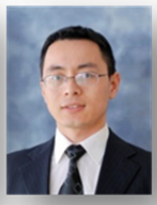

Xiaolei Deng

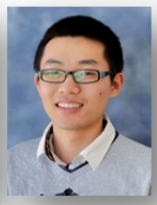

Aleana Gongal


Ruilong Luo


Yasin Osroosh


Patrick Scharf


Meng Wang


Yunxiang Ye


Jingjin Zhang


Jianfeng Zhou

Project Summaries

Intelligent Agricultural Systems for Specialty Crop Production

Sponsor Agency: WSU ARC (Hatch)

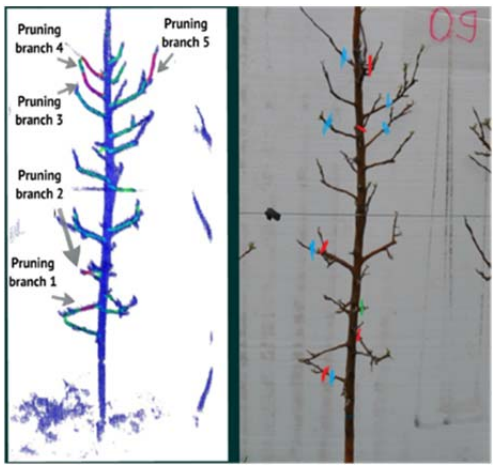
Zhang*, Q.; Karkee, M.

The recent advancement of intelligent agricultural equipment (IAE) technology has made such equipment practical and applicable for agronomic crop production. However, there are still many special challenges to be solved before the technology can be practically applied to specialty crop production. The primary focus of this project is to remove such challenges to make IAE technology practical and applicable for specialty crops production. Specific objectives of this project are to develop mechanization and robotic solutions for production of a wide range of specialty crops, including, but not limited to, fruits and vegetables, hops, grapes and berries, and nursery crops; to find automated solutions for disease/pest monitoring, scouting and controlling in specialty crop production; to develop core technologies for computer-aided worksite management, from data collection and analysis to decision-making support; and to create effective methods for demonstrating and delivering the research outcomes to the stakeholders.

Machine Vision System Development for Automatic Pruning of apple Trees

Sponsor Agency: WSU Office of Research

Karkee, M.



In apple production pruning is a labor intensive operation contributing significantly to total production costs. Automation of this process can significantly reduce these costs. In this research a machine vision based method was developed using a time-of-flight based 3D camera to reconstruct apple trees to identify pruning locations. From this data a skeleton of the tree was rendered and that skeleton was simplified to mark points representing only junctions of branches and trunk. A two step pruning rule was used to identify pruning points. This method achieved an accuracy of approximaely 90% in identifying pruning locations. Further experiments are necessary for physical calibration of 3D skeletons and to develop statistical performance measures. Long term outcomes will be a decrease in manual labor, decreased affects associated with an uncertain labor force, increased profit to growers, and increased sustainability for the apple industry.

Integrated Systems Research and Development in Automation and Sensors for Sustainability of Specialty Crops

Sponsor Agency: USDA NIFA (REEIS)

Zhang*, Q.; Tang, J.; Sablani, S.S.; Lewis, K.M.; Karkee, M.

Specialty crop producers have a need for automated production and post-harvest equipment. Aiming at filling this need by providing required research and development for such equipment, this project adapts biological concepts associated with specialty crop production, harvest, and postharvest handling into quantifiable parameters that can be sensed, develops sensors and sensing systems that can measure and interpret the parameters, and enhances the design and evaluation of automation systems that incorporate varying degrees of mechanization and sensors to assist specialty crop industries with labor, management decisions, and reduction of production costs. The success of the project will be measured by the number of prototypes the participants develop, patents they file, and assistance they provide to industry in the process of developing commercial products.

Placing Fruit Canopy Management Automation Technology in the Field

Sponsor Agency: USDA NIFA (SCRI)

Zhang*, Q.; Karkee, M.; Walters, T.; Whiting, M.D.

Canopy management operations in cane crops are among the most expensive for cane crop production, and the largest expense is labor. Automated technology may replace humans, but must be tailored to the characteristics of the field, and to the size of the farm. The primary goal of this Research and Extension Planning project is to facilitate the development of a research plan for developing automated canopy management technologies suitable for Pacific Northwest cane berry production. The specific objectives include the definition and clarification of the needs for automation in canopy management among western specialty crop producers; the development of comprehensive technical solutions to address automation issues in canopy management; and the formation of partnerships for this trans-disciplinary research and development. A grower-researcher interactive workshop is designed to collect and process stakeholder input, to develop problem statements, and to form the goals of future proposed projects.

Precision Canopy and Water Management of Specialty Crops through Sensor-Based Decision Making

Sponsor Agency: USDA NIFA (SCRI)

Zhang*, Q; Whiting, M.D.; Tan, L.; Peters, R.T. (WSU Team)

This project is a subcontract to a SCRI project with UC Davis as the leading institution. WSU team will contribute to all 9 objectives and will take critical roles in a few: we will refine the sensor system and perform the canopy PAR/shape assessment in tree fruit orchards ; and we will develop a research-grade sensing and mapping system to gather the data for each plant using multiple sensors to predict plant water status. WSU Investigators will lead the development of a visualized decision support system to meet the decision support needs of growers, university researchers; and will be involved in the development and implementation of site-specific application of water and fertilizer using autonomous units. Collaborating with external partners, we will also conduct studies on assessing social impacts of developed innovative technologies through collecting, analyzing and summarizing collected data.

Field Validation of DBR Harvest Assist System Under Washington Conditions

Sponsor Agency: USDA NIFA (SCRI) and WTFRC

Lewis*, K.M., DBR Conveyor Concepts

Mechanized harvest is a documented priority for the Washington State tree fruit industry. The goal of this project is to evaluate a commercial prototype harvest assist system in Washington State apple orchards. DBR Conveyor Concepts of Conklin, MI. have recently developed vacuum tube, decelerator and dry bin filler harvest assist technologies. The technologies will be integrated on a mobile platform and evaluated in Washington apple orchards. Initial focus is on the function and design of individual components and the total system. As warranted, redesign and component modifications will be made throughout field validation phase. Validation studies include: 1) location of impacts that have potential to bruise fruit, 2) incidence and type of bruising, 3) system efficiency and individual worker productivity alone and compared to identical work conducted with ladders and bags. In addition, an ergonomics study will be conducted by the University of Washington, PNASH. Identification and documentation of best management practices will be included in outreach efforts.

Innovative Technologies for Thinning Fruit

Sponsor Agency: USDA NIFA (SCRI) and WTFRC

Lewis, K. (WSU Lead)

Blossom thinning is reported to mitigate alternate bearing in apple and increase final fruit size in both apple and stone fruit. Hand blossom thinning is expensive and requires a large workforce for a short time period. Efficacy and performance of chemical thinning is highly dependent on weather conditions, tree status and application methods. Organic producers have few products to chemically thin fruit. Project investigators have evaluated two non-selective mechanical string thinners and technologies for selective thinning. Field studies include the evaluation of the Darwin and Unibonn string thinners in apple and stone fruit. Replicated field trials compare mechanized bloom thinning, hand bloom thinning, hand green fruit thinning and chemical thinning. To evaluate treatments, data is collected on bloom removal, fruit set, fruit quality and yield. In addition, task efficiency and individual worker productivity is measured and economic analysis is conducted for each treatment.

Development and Optimization of Solid-Set Canopy Delivery Systems for Resource-Efficient, Ecologically Sustainable Apple and Cherry Production

Sponsor Agency: USDA NIFA (SCRI)

Brunner*, J.; Zhang, Q.; Karkee, M.; Whiting, M.; Hanrahan, I.; Schmidt, T.; Xiao, C.-L.; Hoheisel, G.-A. (WSU Team)

This project is a subcontract to a SCRI project with Michigan State University and co-directed by Dr. Brunner of WSU. This project is performed a multidisciplinary research and extension team from three of the major fruit-producing states to develop, evaluate, and deliver resource-efficient, innovative management technologies and tactics for apple and cherry production systems. It aims to establish innovative delivery technologies for canopy and orchard floor inputs (including high efficiency irrigation systems, precision-activated micro-emitters, and reduced risk pesticides) to address critical fruit production needs as identified by commodity PMSPs and the Technology Roadmap for Tree Fruit Production. Direct outcomes of system implementation that will be analyzed include: economic and agro ecosystem impacts. Sociological research will focus on how these integrated technologies impact urban-farm relations, barriers to grower adoption, and how these factors can inform better extension and educational programmatic efforts.

A Total Systems Approach to Developing a Sustainable Stem-Free Sweet Cherry Production, Processing, and Marketing System

Sponsor Agency: USDA NIFA (SCRI)

Whiting*, M.D.; Zhang, Q.; Karkee, M., Dhingra, A.; Oraguzie, N.; Pierce, F.; Ross, C. (WSU Team)

This research is part of a large multi-state, multi-disciplinary research project funded by the USDA's Specialty Crop Research Initiative (SCRI). This four year project began in 2009. The overall research goal is to develop a highly effective sweet cherry production, processing, and marketing system with effective research and outreach programs addressing the entire production chain. Researchers are working closely with industry to solve the challenges of a declining labor supply. The rationale behind this research project is clear: to remain profitable and sustainable, the sweet cherry industry must improve harvest labor efficiency without reducing consumer appeal of fruit. Objectives are addressed in horticulture, genetics & genomics mechanical harvest technologies, packaging & consumer acceptance and economics.

Systems Approach to Superior Pear Fruit Quality

Sponsor Agency: NW Pear Bureau

Dhingra*, A.; Evans, K.; Sablani, S.; Zhang, Q.; Ross, C.

This project uses a systems approach to establishing pear-specific knowledgebase. In the past recommendations for improving pear production, processing and packaging have heavily relied on systems established for apple. However, pears are not apples, and there is an urgent need to reevaluate our approach in how to develop pear-specific solutions for production, post-harvest and processing stages. We plan to utilize this project as a platform to successfully compete for federal USDA-SCRI grant. The specific objectives of this proposal include: to evaluate and devise efficient orchard systems that are amenable to mechanized pruning and harvest using labor assist platforms; to assess the effectiveness of vigor-retarding chemicals like Apogee and Treehold by understanding the underlying gene function; to test the role of cuticle as it relates to fruit quality using microscopy; and to evaluate alternative fruit sanitization platforms like UV or gamma rays in lab settings.

3D Machine Vision for Improved Apple Crop Load Estimation

Sponsor Agency: **WTFRC**

Karkee*, M.; Zhang, Q.; Lewis, K.M.

Accurate estimation of apple cropload is essential for efficient orchard management. In this work, we designed an over the row platform to capture images from two side of apple canopies to minimize the occlusions and improve the accuracy of cropload estimation. A color camera, a 3D camera and a orientation sensor were mounted in the sensor platform and moved down apple rows in three different commercial orchards of Allan Bros. Inc., Prosser, WA. Overall, the images of apples trees were successfully captured from both sides of the row using this platform. Taking images from dual sides showed to be fruitful as more apples were identified which were occluded when viewed from a single side. The next step of the project will be processing of images to identify apples and match it with 3D images to create 3D maps of apples. The sensor-platform system will be improved to make it lighter and easier to operate. Fruit mapping in 3D will minimize duplicated fruit counts and thus improve the accuracy of crop load estimation. Increased accuracy of crop load estimation on a block by block basis would lead to increased efficiencies, a higher level of risk management and increased profitability.

Hand-held Mechanical Thinning Devices for Cherry Production

Sponsor Agency: WTFRC

Zhang*, Q.; Lewis, K.M.

Industry groups have identified crop load management to be a high priority for research and technology development. Blossom thinning is a common practice for crop load management in tree fruit production. Manageable yields of high quality target fruit is the goal of bloom thinning. Mechanized thinning has shown the potential to significantly reduce the dependence on human labor in thinning operations. This research aims to create a hand-held mechanical-assist thinning device which will allow field workers to penetrate inner layers of cherry trees to selectively thin blossoms without using a ladder, and reduce labor dependency through increased operation efficiency and worker productivity. This project will search and review previous attempts on developing such technologies, and analyze the causes of unsuccessful attempts and the key attributers to the successful systems, followed by development of a few “proof-of-concept” prototype systems and conduct field tests to verify their functionality and performance.

Field Phenomics Platform Development

Sponsor Agency: WSU, ARC

Pumphrey*, M.; Brown, D.; Carter, A.; Garland-Campbell, K.; Hulbert, S.; Knowles, R.; Steber, C.; Zhang, Q.

This project is to develop a field research platform and conduct preliminarily tests based on an automatically navigated and steered agricultural tractor. Field-based sensor and imaging devices will be mounted on the platform to efficiently collect data related to crop productivity, input-efficiency, and health while simultaneously applying methods to determine and account for spatial variation due to soil heterogeneity. This automated field research platform, with state-of-the-art imaging, sensing, and positioning/guidance systems, will be capable of rapid, in situ, assessment of crop nutrient and water status, crop health, vigor and productivity, and other important characteristics.

Intelligent Bin-Dog System for Tree Fruit Production

Sponsor Agency: WTFRC

Zhang*, Q.; Lewis, K.M.; He, L.

The tree fruit industry needs technological innovations which can assist growers in maintaining a competitive position in the global marketplace. High labor demand, associated costs and rigorous regulations, requires the industry to adopt mechanical and/or automated approaches to solve production system challenges. This ***second phase*** project will be focused on developing a prototype of an actual "bin-dog" system capable of helping human pickers to achieve the goals of more efficient harvesting with better fruit quality, improved worksite safety and superior production and quality traceability. The core capabilities of the "bin-dog" include (1) carrying one fruit bin within the vicinity of picker harvesting zone; and (2) traveling within typical WA tree fruit orchards.

Multispectral Image Analyses of Potatoes under Different Nutrient Management with Center Pivot Irrigation

Sponsor Agency: USDA ARS Prosser Vegetable and Forage Crop Research Unit

Alva*, A.; Zhang, Q.; Karkee, M.

This research project aims to investigate the feasibility of non-destructive estimation of nutritional status of potato canopy using multispectral imaging and prediction of tuber yield and quality response to variable nutrient management under pivot irrigation. Spectral characteristics of vegetation are a quantitative measure and can offer a non-destructive method to assess crop nutrition; biomass production; yield and quality of crop products. This type of sensing technology has been successfully developed for detecting nitrogen stress in agronomic crops, but little research has been reported on effectively and accurately measuring the nutritional status of potato plants in irrigated production systems using multispectral images. This project will modify the technology to potato production under center pivot irrigation. Furthermore, multispectral image sensing can be an efficient tool of non-destructive evaluation of potential non-uniformity in water distribution in center pivot irrigation system.

Conversion of High-Yield Tropical Biomass into Sustainable Biofuels

Sponsor Agency: USDA NIFA (BRDI)

Zhang*, Q.; Karkee, M. (WSU Team)

In this project, we are undertaking tasks of improving harvesting mechanisms for effective and efficient harvesting of tropical crops for biomass. The target crops are sugar cane, energy cane, sweet sorghum, and Napier grass. First, we will perform laboratory simulation studies to identify limitations of current cutting and conveying mechanisms. At the same time, we will carry out field evaluation of existing machine to collect baseline machine performance data. Based on the knowledge acquired from the field and lab tests, we will improve and optimize cutting and conveying mechanism for tropical biomass harvesting. Improved mechanisms will be evaluated in the field in Hawaii.

Developing Apple Harvesting Techniques

Sponsor Agency: WTFRC

Karkee, M.*; De Kleine, M.; Lewis, K.M.; Zhang, Q.

Fresh market apple harvesting is currently done using manual labor in all fruit growing regions in the world. Because the labor cost is increasing and labor availability is increasingly uncertain, mechanized harvesting solutions are critically important for the sustainability of apple industry. In this work, a concept for fresh market apple harvesting was developed and tested for trellised orchards in Washington State. The harvesting technique uses bi-directional rotating rubber wheels to rotate an apple from a fruiting wall trellised-branch. Rotation was varied between clockwise and counter-clockwise directions. A new prototype harvester is being developed that will have multiple wheels and will act on several apples at a time.

Evaluating Non-Newtonian Fluid-based Surface for Fruit Catching

Sponsor Agency: WSU Faculty Start-Up Fund

Karkee, M.*;De Kleine, M.

Drop heights and fruit contact surfaces are important to engineers designing machinery and processing equipment. In this study, various drop tests were conducted using an instrumented sphere, peaches, pears, and apples. The instrumented sphere was dropped on three surfaces: a tiled floor, a human hand, and a non-Newtonian shear-thickening surface composed of cornstarch and water. For use as a damage boundary in harvesting and handling procedures, a shear-thickening non-Newtonian fluid surface can limit acceleration and velocity of moving fruits. Reducing the impact forces will reduce the bruise rates during handling.

Student Projects

Machine Vision System Development for Shake and Catch Cherry Harvesting

Sponsor Agency: Self-funded

Amatya, S.; Karkee, M.

This project is aimed at identifying branches of cherry trees for harvesting cherries using mechanical limb shakers. Automation in cherry harvesting using mechanical shakers requires sensors that can guide robotic arm to the branches. The machine vision system will help to identify branches for locating shaking points. Color cameras are used to acquire images of cherry trees.

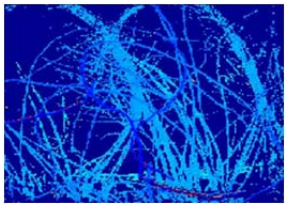


Image processing techniques are used to segment branches from the background. Processing images captured from different cameras by single algorithm is challenging due to variation in camera parameters. Therefore, branch identification was done with images captured from a single camera. In the future, the algorithm to identify cherry branches will be further improved.

Agricultural Automation Engineering Club

Student social gathering after club meeting

Current Projects/Grants

Development and Optimization of Solid-Set Delivery Systems for Resource Efficient, Ecologically Sustainable Apple and Cherry Production (USDA SCRI Project)CPAAS lead: Zhang	$771,391
Precision Canopy and Water Management of Specialty Crops through Sensor-Based Decision Making (USDA SCRI Project) CPAAS lead: Zhang	$666,246
Comprehensive Automation for Specialty Crops (USDA SCRI) CPAAS lead: Lewis	$621,670
Innovative Techniques for Thinning Fruit (USDA SCRI) CPAAS lead: Lewis	$107,267
Placing fruit canopy management automation technology in the field (USDA SCRI);CPAAS lead: Zhang	$49,479
A Total Systems Approach to Developing a Sustainable, Stem-free Sweet Cherry Production, Processing, and Marketing System (USDA SCRI); CPAAS lead :Whiting	$3,891,952
Conversion of High-Yield Tropical Biomass into Sustainable Biofuels (USDA BRDI);CPAAS lead: Zhang	709,233
Six (6) projects from Commodity Commissions of WA and Oregon: CPAAS leaders: Zhang, Karkee, Lewis, Whiting,	$181,969
One (1) collaborating project with USDA ARS (Prosser, WA):CPAAS lead: Zhang, Karkee	$19,129
Total	$7,018,336

2012 Proposals pending as of February 2013

Human-machine collaboration for automated harvesting of tree fruit (NSF-NRI); CPAAS lead: Karkee	$582,006

Peer Reviewed Journal Articles

1. Yue, C., R.K. Gallardo, V. McCracken, J. Luby, J. McFerson, L. Liu, and A. Iezzoni. 2012. Technical and Socio-Economic Challenges to Setting and Implementing Priorities in North American Rosaceous Fruit Breeding Programs. HortScience, 47:1320-1327.

2. Gallardo, R.K., D. Nguyen, V. McCracken, C. Yue, J. Luby, and J. McFerson. 2012. An Investigation of Trait Prioritization in Rosaceous Fruit Breeding Programs. HortScience, 47: 771-776.

3. Hudson, D., R.K. Gallardo, and T. Hanson. 2012. A Comparison of Choice Experiments and Actual Grocery Store Behavior: An Empirical Application to Seafood Products. Journal of Agricultural and Applied Economics, 44: 49-62.

4. He, L., X. Du, R. Luo, M. Karkee, Q. Zhang. 2012. A Twining Robot for High Trellis String Tying in Hops Production. Transactions of ASABE, 55: 1167-1673.

5. Karkee, M., R. McNaull, S.J. Birrell, B.L. Steward. 2012. Estimation of Optimal Biomass Removal Rate Based on Tolerable Soil Erosion for Single-Pass Crop Grain and Biomass Harvesting System. Transactions of the ASABE, 55: 107-115.

6. Abd Aziz, S., B.L. Steward, A. Kaleita, and M. Karkee. Assessing the Effects of DEM Error Uncertainty on Soil Loss Estimation in Agricultural Field. Transactions of the ASABE, 55: 785-798.

7. Hehnen, D., I. Hanrahan, K.M. Lewis, J. McFerson, and M.M. Blanke. 2012. Mechanical thinning improves fruit quality and provides consistent bearing in apple. Scientia Horticulturae, 134: 241-244.

8. Ampatzidis, Y., M.D. Whiting, P.A. Scharf, and Q. Zhang. 2012. Development and evaluation of a novel system for monitoring harvest labor efficiency. Computers and Electronics in Agriculture, 88: 85-94.

9. Ampatzidis, Y., M.D. Whiting, P. Scharf, and F.J. Pierce. 2012. Portable weighing system for monitoring picker efficiency during manual harvest of sweet cherry. Precision Agriculture, DOI 10.1007/s11119-012-9284-3 (IF – 1.5)

10. Ampatzidis, Y., Q. Zhang, and M.D. Whiting. 2012. Comparing the efficiency of future harvest technologies for sweet cherry. Acta Hortic., 965: 195-198.

11. Ampatzidis, Y.G., S.G. Vougioukas, and M.D. Whiting. 2012. A wearable module for recording worker position in orchards. Computers and Electronics in Agriculture, 78: 222-230.

12. Du, X., D. Chen, Q. Zhang, P.A. Scharf, and M.D. Whiting. 2012. Dynamic Responses of Sweet Cherry Trees under Vibratory Excitations. Biosystems Engineering, 111: 305-314.

13. Puniran, N., D.C. Close, S.A. Bound, R. Corkney, and M.D. Whiting. 2012. Fruit colour, size and temperature affect the shelf life of sweet cherry. Acta Hortic. 934: 995-1001.

14. Whiting, M.D., A. Dhingra, N. Oraguzie, F. Pierce, Q. Zhang, T. Arnold, E. Almenar, J. Harte, C. Ross, C. Seavert, L.Long, and J Grant. 2012. A total systems approach to

developing a sustainable stem-free sweet cherry production, processing, and marketing system. Acta Hortic., 965: 131-140.

15. Boman, B., B. Sanden, R.T. Peters, and L. Parsons. 2012. Current Status of Microsprinkler Irrigation in the United States. Applied Engineering in Agriculture, 28: 359-366.

16. Kranz, W.L., R.G. Evans, F.R. Lamm, S.A. O'Shaughnessy, and R.T. Peters. 2012. A Review of Center Pivot Sprinkler Irrigation Control and Automation Technologies. Applied Engineering in Agriculture, 28: 389-397.

17. Lamm, F. R., J. P. Bordovsky, L. J. Schwankl, G. L. Grabow, J. Enciso- Medina, R. T. Peters, P. D. Colaizzi, T. P. Trooien, and D. O, Porter. 2012. Subsurface drip irrigation: Status of the technology in 2010. Transactions of the ASABE, 55: 483-491.

18. Mobbs, T.L., R.T. Peters, J.R. Davenport, M.A. Evans, and J.Q. Wu. 2012. Effects of Four Soil Surfactants on Four Soil-Water Properties in Sand and Silt Loam. Journal of Soil and Water Conservation, 67: 275-283.

19. Noh, H., and Q. Zhang, 2012. Shadow effect on multi-spectral image for detection of nitrogen deficiency in corn. Computers and Electronics in Agriculture, 83: 52–57.

20. Wang, Q., H. Wang, L. Xie, and Q. Zhang. 2012. Outdoor color rating of sweet cherries using computer vision. Computers and Electronics in Agriculture, 87: 113–120.

21. Kang, F., H. Wang, F. Pierce, Q. Zhang, and S. Wang. 2012. Sucker detection of grapevines for targeted spray using optical sensors. Transactions of the ASABE, 55: 2007-2014.

22. Wang, L., H. Lei, S. Ren, Q. Bu, J. Liang, Y. Wei, Y. Liu, J. Lee, S. Chen, J. Tang, Q. Zhang, R. Ruan. 2012. Aromatics and phenols from catalytic pyrolysis of Douglas fir pellets in microwave with ZSM-5 as a catalyst. Journal of Analytical and Applied Pyrolysis, 98: 194-200.

23. Bu, Q., H. Lei, A. Zacher, L. Wang, S. Ren, J. Liang, Y. Wei, Y. Liu, J. Tang, Q. Zhang, and R. Ruan. 2012. A review of catalytic hydrodeoxygenation of lignin-derived phenols from biomass pyrolysis. Bioresource Technology, 124: 470-477.

24. Bu, Q., H. Lei, S. Ren, L. Wang, Q. Zhang, J. Tang, and R. Ruan. 2012. Production of phenols and biofuels by catalytic microwave pyrolysis of lignocellulosic biomass. Bioresource Technology, 108: 274-279.

25. Chen, D., X. Du, Q. Zhang, M.D. Whiting, P.A. Scharf, and S. Wang 2012. Performance evaluation of mechanical cherry harvesters for fresh market grade fruits. Applied Engineering in Agriculture, 28: 483-489.

26. Du, X., D. Chen, Q. Zhang, P.A. Scharf, and M.D. Whiting. 2012. Dynamic responses of sweet cherry trees under vibratory excitations. Biosystems Engineering, 111: 305–314.

27. He, L., Q. Zhang, X. Du, R. Luo, and M. Karkee. 2012. A twining robot for high-trellis string tying in hops production. Transactions of the ASABE, 55: 1667-1673.

28. Tan, L., S. Xu, B. Meyer, and B. Erwin. 2012. An extensible object-oriented and agent-based framework for modeling and simulating supply chains. International Journal of Information and Decision Sciences, 4: 251-267.

29. Kangas, L., T. Metz, G. Isaac, B. Schrom, B. Ginovska, L. Wang, L. Tan, R.R. Lewis, and J.H. Miller. 2012. In silico identification software (ISIS): a machine learning approach to tandem mass spectral identification of lipids. Bioinformatics, 28: 1705-1713.

Proceedings & Conference Papers

1. Amatya, S., M. Karkee, A. K. Alva, P. A. Larbi, and B. Adhikari. 2012. Hyperspectral Imaging for Detecting Water Stress in Potatoes. ASABE Paper No. 121345197. St. Joseph, Mich.: ASABE.

2. Ampatzidis, I., A. Bikram, M.D. Whiting, and Q. Zhang. 2012. Preliminary Testing of a System for Evaluating Picker Efficiency in Tree Fruit. ASABE Paper number 12-1338439, St. Joseph, Mich.: ASABE.

3. Brown, S., X. Zhang, H. Wang, Z. Dai, L. Tan, and B. Yang. 2012. Dynamic Characterization of Enzymatic Hydrolysis of Cellulose via a Broadband Stimulated Raman Spectroscopy. Proceedings of the 34th Symposium on Biotechnology for Fuels and Chemicals.

4. Carter, P.G. 2012. Adoption barriers to precision agriculture technologies. 11th Annual Western Region NACAA Extension Professional Development Conference. p.21. Twin Falls, ID.

5. Gallardo, R.K. 2012. Applied Economics and Fruit Quality. Presentation at the Seminar Series organized by the Academic Office for Extension and Social Projection. National Agrarian University, La Molina, Lima, Peru, December 13.

6. Gallardo, R.K. and A. Olanie. 2012. The Use of Wireless Capability at Farmers Markets: Results from a Choice Experiment Study. Selected Paper presented at the Agricultural and Applied Economics Association Annual Meetings. Seattle, WA. August 12-14.

7. Girma, K., S. Fransen, R.O. Okwany, R.T Peters, W. Pan, H.P. Collins and J. Davenport. 2012. Soil Profile nitrogen under different biofuel feedstock grasses and irrigation regimes. Northwest Bioenergy Research Symposium, Nov 13, 2012, Seattle WA.

8. Hashimoto, A., J. Arnold, J. Ayars, S. Crow, T. Eggeman, L. Jakeway, M. Karkee, S. Khanal, J. Kiniry, J. Matsunaga, G. Murthy, M. Nakahata, R. Ogoshi, B. Turano, S. Turn, J. Yanagida, and Q. Zhang. 2012. High-Yield Tropical Biomass for Advanced Biofuels. Sun Grant Initiative National Conference, New Orleans, LA; Oct 2-5, 2012.

9. He, L., J. Zhou, P. Scharf, and Q. Zhang. 2012. Energy Efficiency Analysis of a Mechanical Shaker for Sweet Cherry Harvest. International Symposium on Mechanical Harvest & Handling Systems of Fruits and Nuts.

10. He, L., J. Zhou, X. Du, D. Chen, Q. Zhang, and M. Karkee. 2012. Shaking Energy Delivery on Sweet Cherry Trees in Different Excitation Models. ASABE Paper No. 12-1337766. St. Joseph, Mich.: ASABE.

11. Karkee, M., and Q. Zhang. 2012. Mechanization and Automation Technologies in Specialty Crop Production. Invited Article, ASABE Resource Magazine, Sep/Oct 2012: 16-17.

12. Kohanbash, D., M. Bergeman, K.M. Lewis, and S. Moorehead. 2012. A Safety Architecture for Autonomous Agricultural Vehicles. ASABE Paper number 12-1337110, St. Joseph, Mich.: ASABE.

13. Lewis, K.M., and M. Robinson. 2012. Mechanized String Thinners – an effective tool for cropload management in organic apricot production. ISHS Program and Abstract Book, pg 14 – 2nd Annual International Organic Fruit Research Symposium. eExtension YouTube Channel.

14. Lou, R., Q. Zhang, and K.M. Lewis. 2012. Assessment of Bruise Damage Caused by Vacuum Apple Harvest Assist Prototype. ASABE Paper number 12-1338094, St. Joseph, Mich.: ASABE.

15. M.E. Barber, J.C. Adam, M. Brady, K. Chinnayakanahalli, S. Dinesh, C. Kruger, R.T. Peters, K. Rajagopalan, C. Stockle, J. Yoder, and G. Yorgey, Climate Change Impacts on 2030 Water Supply and Demand in the Columbia River Basin. 3rd Annual Pacific Northwest Climate Science Conference, Boise, ID. October 2012.

16. Monga, M., M. Karkee, S. Sun, L. K. Tondehal, B. L. Steward, A. Kelkar, and J. Zambreno. 2012. Real-time Simulation of Dynamic Vehicle Models using a High-performance Reconfigurable Platform. International Conference on Computational Science, ICCS 2012, June 4-6, 2012, Ames, IA 50011 USA.

17. Tan, L., R. Haley, R. Wortman, and Q. Zhang. 2012. An extensible and integrated software architecture for data analysis and visualization in precision agriculture. The Proceedings of 2012 IEEE Information Reuse and Integration

18. Toro-Gonzalez, D., J. Yan, R.K. Gallardo, and J.J. McCluskey. 2012. Demand Estimation: Unobservable Quality in Mint Gum. Selected Paper presented at the Agricultural and Applied Economics Association Annual Meetings. Seattle, WA. August 12-14.

19. Wang, M., Q. Zhang, and K.M. Lewis. 2012. End-effector Performance of a Hand-held Mechanical Bloom Thinning Device. ASABE Paper number 12-1338048, St. Joseph, Mich.: ASABE.

20. Yue, C., R.K. Gallardo, J. Luby, A. Rihn, J. McFerson, V. McCracken, D. Bedford, S. Brown, K. Evans, C. Weebadde, A. Sebolt, and A. Iezzoni. 2012. An Investigation of United States Apple Producers Trait Prioritization - Evidence from Clicker Surveys. Paper presented at the American Society for Horticultural Science Annual Meetings, Miami, FL. July 29 – Aug 2.

21. Zeng, B., and L. Tan. 2012. Test Criteria for Model-Checking-Assisted Test Vector Generation: A Computational Study. Proceedings of 2012 IEEE Information Reuse and Integration, 2012 IEEE Information Reuse and Integration, Las Vegas.

22. Zhou, J. L. He, X. Du, D. Chen, Q. Zhang, and M. Karkee. 2012. Dynamic Response of Sweet Cherry Tree to the Vibration of a Limb Shaker. ASABE Paper No. 12-1337429. St. Joseph, Mich.: ASABE.

23. Zhou, J., L. He, P. Scharf, and Q. Zhang. 2012.. Fruit Removal Efficiency of a Limb Shaker for Sweet Cherry Harvest. International Symposium on Mechanical Harvest & Handling Systems of Fruits and Nuts.

Extension Publications

1. Gallardo, R.K. and S. Galinato. Cost Estimates of Establishing, Producing, and Packing Red Delicious Apples in Washington. Washington State University Extension Factsheet FS099E, December 2012.

2. Gallardo, R. K. and S. Galinato. Cost of Producing Peppermint under Rill and Center Pivot Irrigation in Washington. Washington State University Extension Factsheet FS077E, August 2012.

3. Galinato, S. and R.K. Gallardo. Cost Estimates of Establishing, Producing, and Packing Honeycrisp Apples in Washington. Washington State University Extension Factsheet FS062E, February 2012.

4. M. Moyer, R.T. Peters, and R. Hamman. 2012. Irrigation Basics for Eastern Washington Vineyards. WSU Peer Reviewed Extension Publication. EM061E

5. Peters, R.T., and J.R. Davenport. 2012. Managing Irrigation Water on Different Soils in the Same Field. WSU Peer Reviewed Extension Publication. FS086E

6. Peters, R.T., Kefyalew Desta, and L. Nelson. 2012. Practical Use of Soil Moisture Sensors for Irrigation Scheduling. Accepted and In Press. Pub# 2012-0659

Invited Presentations

1. Carter, P.G. 2012. Adoption barriers to agriculture technologies. International Precision Agriculture Centers Conference. WSU CPAAS. Richland, WA.

2. Carter, P.G. 2012. Adoption barriers to precision agriculture technologies. 11th Annual Western Region NACAA Extension Professional Development Conference. Twin Falls, ID.

3. Hoheisel, G. 2012. Growing Backyard Grapes. Clarkston/Lewiston Master Garderners, Clarkston, WA.

4. Hoheisel, G. 2012. Importance of Sprayer Calibration. Pesticide Education Program Recertification, Pasco, WA.

5. Hoheisel, G. 2012. Sprayer Calibration: How and Why. Washington Association of Wine Grape Growers Annual Meeting, Convention & Trade Show, Kennewick, WA.

6. Hoheisel, G. 2012. Sprayer Technology and Efficacy. GSL Hop/Grape Annual Grower Meeting, Yakima, WA.

7. Hoheisel, G. 2012. Tips for Effective Vineyard Spraying. Washington Association of Wine Grape Growers Annual Meeting, Convention & Trade Show, Kennewick, WA.

8. Hoheisel, G. 2012. Update on Marmorated Stink Bug and Spotted Wing Drosophila. Pesticide Education Program Recertification, Pasco, WA.

9. Hoheisel, G. 2012. Using a Key for Insect ID. 2012 Master Gardener Training Program, Kennewick, WA

10. Karkee, M. 2012. Agricultural Automation Research at WSU – Tribhuvan University, Nepal.

11. Karkee, M. 2012. Agricultural Automation Research at WSU – Universiti Putra Malaysia.

12. Karkee, M. 2012. Precision Agriculture in Specialty Crops: Accomplishments, Challenges and Future Direction. First International Precision Agriculture Forum, Richland, WA.

13. Karkee, M. 2012. Pruning Branch Identification for Automated Pruning of Apple Trees, Specialty Crop Engineering Solutions Workshop, Pittsburg, PA.

14. Karkee, M. 2012. Automation and Mechanization Research for Specialty Crops, Annual Hermiston Farm Fair and Trade Show, Hermiston, OR.

15. Kulczewski, M. and K. Lewis. 2012. Mechanized Thinning in Sweet Cherry – The Washington and Chilean Experience. International Fruit Tree Association Annual Meeting. Santiago, Chile.

16. Lewis, K.M. 2012. Automation and Mechanization in PNW Orchards. Nelson Fruit Growers Annual Meeting. Nelson, New Zealand.

17. Lewis, K.M. 2012. Automation and Mechanization in Tree Fruit Production. WA Growers League Annual Meeting. Yakima, WA.

18. Lewis, K.M. 2012. Engineering Solutions for Stone Fruit Production. NCW Stone Fruit Day. Wenatchee, WA.

19. Lewis, K.M. 2012. Mechanical Bloom Thinning in Sweet Cherry. Cherry Institute. Yakima, WA

20. Lewis, K.M. 2012. Mechanical Solutions for Thinning and Harvest. Washington State Horticultural Association Annual Meeting. Yakima, WA.

21. Lewis, K.M. 2012. Technology Research Update –what you are funding and what are we delivering. Chelan Fruit Growers Annual Meeting. Chelan, WA.

22. Zhang, Q. 2012. Agricultural System Control. International Forum on Precision Agriculture, Richland, WA, USA.

23. Zhang, Q. 2012. Agricultural Systems and Controls. IFAC Symposium on Dynamics and Control in Agriculture and Food Processing, Plovdiv, Bulgaria.

24. Zhang, Q. 2012. Precision Agriculture and Agricultural Controls. International Forum on Innovative Development Strategy for Agricultural and Biological System Engineering, Beijing, China.

25. Zhang, Q. 2012. The ATOE Conference: Past, Present and Future. CIGR Symposium on Automation Technology for Off-road Equipment, Valencia, Spain.

26. Zhou, J., L. He, and Q. Zhang. 2012. Mechanical Harvesting of Sweet Cherries for Fresh Market. 2012 Annual Meeting of Washington State Horticultural Association

Posters/Abstracts

1. Adhikari, B., and M. Karkee. 2012. 3D Reconstruction of Apple Trees for Mechanical Pruning. WSU Academic Showcase, March 30, 2012, Pullman, WA.

2. Ampatzidis, I., M.D. Whiting, and Q. Zhang. 2012. Comparing the Efficiency of Future Harvest Technologies for Sweet Cherry. International Symposium on Mechanical Harvesting & Handling Systems of Fruits and Nuts, Lake Alfred, FL.

3. Ampatzidis, I., R. Wortman, R. Haley, L. Tan, and M.D. Whiting. 2012. Harvest Management Information System. HortShow, December 3-5, Yakima WA HortShow, Yakima WA.

4. Ampatzidis, Y., R. Haley, R. Wortman, L. Tan, and M.D. Whiting. 2012. Harvest Management Information System. The annual meeting of Washington State Horiculture Association.

5. De Kleine, M.E., M. Karkee, K. Lewis, and Q. Zhang. 2012. Apple Harvesting Techniques. 108th WSHA Annual Meeting. Dec 3-5, Yakima, WA.

6. De Kleine, M.E., and M. Karkee. 2012. A non-Newtonian Shear Thickening Surface for Fruit Impact Bruising Evaluation. 108th WSHA Annual Meeting. Dec 3-5, Yakima, WA.

7. Gallardo, R.K. 2012. Center for Precision and Automated Agricultural Systems Technology Expo at Sunrise Orchards, Washington State University, Rocky Island, WA. October 2.

8. Gallardo, R.K. 2012. The International Symposium on Mechanical Harvesting and Handling Systems of Fruits and Nuts. Lake Alfred, FL. April 1-4.

9. Gallardo, R.K., K.M. Lewis, I. Hanarahan and C. Seavert. 2012. Preliminary Validation of Harvest Assist Systems for Washington Apples. ISHS International Symposium on Mechanical Harvest of Fruit and Nuts. Lake Alfred, FL.

10. Gongal. A, B. Adhikari, S. Amatya, M. Karkee, Q. Zhang, and K. Lewis, 2012. 3D Machine Vision for Improved Apple Crop Load Estimation. CPAAS Tech Expo. October 2, Wenatchee,WA.

11. Gongal. A, B. Adhikari, S. Amatya, M. Karkee, Q. Zhang, and K. Lewis, 2012. 3D Machine Vision for Improved Apple Crop Load Estimation. 108th WSHA Annual Meeting, Poster Session. Dec 3 – 5, Yakima, WA.

12. He, L., K.M. Lewis, P. Scharf, M. Wang, Y. Ye, Q. Zhang, and J. Zhou. 2012. Intelligent Bin-dog Systems for Tree Fruit Production. Washington State Horticultural Association Annual Meeting. Yakima, WA.

13. Iezzoni, A., C. Peace, N. Bassil, M. Coe, G. Fazio, K. Gallardo, K. Gasic, J. Luby, D. Main, J. McFerson, E. Van de Weg, C. Weebadde, and C. Yue. 2012. Extending Marker-Assisted Breeding Capability to a Wider Range of Rosaceous Crops, Traits, and Germplasm. Poster presentation at the 6th Rosaceous Genomics Conference, Trento, Italy. September 30-October 4.

14. Kohanbash, D., M. Bergeman, K.M. Lewis, and S. Moorehead. 2012. A Safety Architecture for Autonomous Agricultural Vehicles. ASABE Annual Meeting, Dallas, Texas.

15. Larbi, P.A., M. Karkee, and I, Hanrahan. 2012. Prospective of Hyperspectral Imaging Techniques for Predicting Chilling Injury Incidence in Honeycrisp™ Apples. 108th WSHA Annual Meeting, Poster Session. Dec 3 – 5,, Yakima, WA.

16. Larbi, P.A., M. Karkee, S. Amatya, M. De Kleine, Q. Zhang, and M.D. Whiting. 2012. Modification and Testing of an Experimental Sweet Cherry Harvester. 108th WSHA Annual Meeting, Poster Session. Dec 3 – 5,, Yakima, WA.

17. Lewis K. M., and I. Hanrahan. 2012. Evaluation of Two Harvest Assist Systems Under Washington State Conditions. ISHS International Symposium on Mechanical Harvest of Fruit and Nuts. Lake Alfred, FL.

18. Lewis, K.M., and M. Robinson. 2012. Mechanized String Thinners – an effective tool for cropload management in organic apricot production. ISHS 2nd Annual International Organic Fruit Research Symposium, Leavenworth, WA.

19. Li, H., R.K. Gallardo, V. McCracken, C. Yue, J. Luby, and J. McFerson. 2012. Market Intermediaries' Willingness-to-Pay for Rosaceous Tree Fruit Attributes. Poster Presentation at the WA Horticultural Association Annual Meetings, Yakima, WA. December 3-5.

20. Lou, R., Q. Zhang, and K.M. Lewis. 2012. Assessment of Bruise Damage Caused by Vacuum Apple Harvest Assist Prototype. ASABE Annual Meeting, Dallas, Texas.

21. Sharda A., M. Karkee, and Q. Zhang. 2012. Pressure dynamics in solid set canopy spray application system for tree fruit orchards. Washington State Horticultural Association 108th Annual Meeting and Trade Show, Yakima, WA. December 3-5.

22. Sharda A., M. Karkee, Q. Zhang, and I. Ewlanow. 2012. Effect of nozzle type, location and orientation around tree canopy on product coverage for solid set canopy delivery system. Washington State Horticultural Association 108th Annual Meeting and Trade Show, Yakima, WA. December 3-5.

23. Tan, L., R. Haley, R. Wortman, M. O'Toole, and S. Curtis. 2012). AgriD: A data visualization, analysis, and decision support tool for precision farming. WSU CPAAS Expo, October 2, Wenatchee,WA.

24. Wang, M., Q. Zhang, and K.M. Lewis. 2012. End-effector Performance of a Hand-held Mechanical Bloom Thinning Device. ASABE Annual Meeting, Dallas, Texas.

Popular Press/Newsletters/Videos

1. Gallardo, R.K. 2012. Consumer Taste Panels. RosBREED Newsletter, November. Available at: http://www.rosbreed.org/sites/default/files/2011-05-31_RosBREED_Newsletter.pdf

2. Gallardo, R.K. and J. McFerson. 2012. Good to Know, What Growers Want in New Varieties. Good Fruit Grower, November. Available at: http://www.goodfruit.com/Good-Fruit-Grower/November-2012/Good-to-KnowWhat-growers-want-in-new-varieties/

3. Gallardo, R.K Good Fruit Grower. 2012. Red's not dead. December. Available at: http://www.goodfruit.com/Good-Fruit-Grower/December-2012/Reds-not-dead/

4. Gallardo, R.K Good Fruit Grower. 2012. Cost of Growing Reds. December. Available at: http://www.goodfruit.com/Good-Fruit-Grower/December-2012/Cost-of-growing-Reds/

5. Gallardo, R.K Seattle Weekly Blogs. 2012. Honeycrisp Growers Dependent on Current Demand. March 7. Available at: http://blogs.seattleweekly.com/voracious/2012/03/honeycrisp_growers_dependent_o.php

6. Gallardo, R.K Good Fruit Grower. 2012. Honeycrisp Profitability. January, pp. 13.

7. Hoheisel, G., Lewis, K.M., Singh, S., Bergerman, M., & Yung, I. 2012. Phil Brown Apple Harvester. http://www.cascrop.com/.

8. Hoheisel, G., Lewis, K.M., Singh, S., Bergerman, M., & Yung, I. 2012. Autonomous Platform Cascade. http://www.cascrop.com/.

9. Hoheisel, G., Singh, S., Bergerman, M., & Yung, I. 2012. Electronic Trap. http://www.cascrop.com/.

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11. Hoheisel, G., Baugher, T., Singh, S., Bergerman, M., & Yung, I. 2012. Placing Pheromones. http://www.cascrop.com/.

12. Hoheisel, G., Baugher, T., Singh, S., Bergerman, M., & Yung, I. 2012. Hand Fruit Thinning. http://www.cascrop.com/.

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Outreach

The following are examples of outreach activities made by Center faculty, staff and students to foster academic collaboration between other institutions and to deliver technology to growers and stakeholders.

Field Days, Educational Tours and Technology Demonstrations

Matt Whiting hosted a *demonstration of the labor monitoring system*; Prosser, WA; Nov 6, 2012.

CPAAS organized and hosted *CPAAS Technology Expo*, Sunrise Orchard, Wenatchee, WA; Oct 2, 2012.

CPAAS organized *technology demonstration to Washington Governor Gregoire* (accompanied by Vice President, Dean Dan Bernardo toured) and other state government officials, Prosser, WA; Aug 2, 2012.

Matt Whiting organized and hosted C*herry Field Day* (Manoj Karkee and Qin Zhang participated), Yakima Valley, WA; June 4, 2012.

Qin Zhang organized and hosted the *First International Forum on Precision Agriculture* (22 academic and industry research leaders in precision agriculture from 7 countries participated); Richland, WA; March 15-16, 2012.

Manoj Karkee and Karen Lewis organized *a Study Tour to 2012 Tulare World Agriculture Expo* (Manoj Karkee, Karen Lewis, Qin Zhang, Karina Gallardo, and Patrick Scharf from CPAAS and eight WA tree fruit growers participated); Tulare, CA; February 13-17, 2012.

Other Outreach Activities

January

Karina Gallardo gave presentation on 'Production Costs in Tree Fruit. What have we learned?' in Spanish at New York Fruit and Vegetable Expo; Syracuse, NY; January 26, 2012.

S. Brown and Karina Gallardo give presentation on 'Tell Us What you Want! Quantifying your Priorities for New Apple Cultivars' at the New York Fruit and Vegetable Expo; Syracuse, NY. January 25. 2012.

Karen Lewis makes presentation at Cherry Institute on Mechanical Thinning; Yakima, WA; 13 January, 2012

Karen Lewis makes presentation on mechanical thinning in cherries at NCW Stone Fruit Day; Wenatchee, WA; 20 January, 2012.

Matt Whiting discusses mechanical harvest technologies for sweet cherry with industry at Cherry Institute; Yakima, WA; January 13, 2012.

Matt Whiting met with industry representatives to discuss mechanical pollination technologies for apple and cherry at Cherry Institute; Yakima, WA; January 13, 2012

Matt Whiting gives presentation on sweet cherry SCRI research at the North Central Washington Stone Fruit Day; Wenatchee, WA; 20 January, 2012.

Matt Whiting gives a presentation on “A total systems approach to renovating the sweet cherry industry” to Californian cherry growers; Stockton, CA; Jan 24, 2012.

Matt Whiting leads orchard tour of UFO blocks in California; San Joaquin Valley, CA; January 23, 2012.

Troy Peters gives presentation on ‘Consumptive Use and Irrigation Water Requirements for Washington State’ at NRCS State Technical Advisory Committee Review; Spokane, WA; January 23, 2012.

Troy Peters gives presentation on ‘Irrigation of Grapevines’ at Hort 521 Lecture; Prosser, WA; January 24, 2012.

Troy Peters gives presentation on ‘Irrigation of Cranberries’ at Cranberry Winter Grower’s Meeting; Raymond, WA; January 3, 2012.

February

R.K. Gallardo. Production Costs in Tree Fruit. What have we learned? Presentation given in Spanish to WSU Douglas-Chelan County Extension Seminar on Pesticide Application, Spanish Section. Wenatchee, WA. February 7. 2012.

Matt Whiting gives presentation on mechanical harvest technologies for sweet cherries at Cherry Research Review (The Dalles, OR 3 February)

Matt Whiting holds pruning demonstration in peach orchard (Prosser, WA: 6 February)

Qin Zhang, Manoj Karkee, Matt Whiting and Linda Root participated in a cane berry canopy management research plan meeting at Mt. Vernon (February 21-22, 2012)

R.K. Gallardo, AgTools™ Academy Online Workshop for Tree Fruits, with Clark Seavert. February 29, 2012. Available at: https://agtools.webex.com/agtools/ldr.php?AT=pb&SP=MC&rID=104636602&rKey=ee44d38d638536ec

Manoj Karkee organized a planning meeting in Mt. Vernon, WA to discuss about small fruit industry need in canopy management automation area. Four researchers and seven small fruit industry representatives/growers participated in the meeting (Direct Contact: 15 people). Feb 21-22, 2012

Matt Whiting coordinated meeting with industry to demonstrate the labor monitoring system (Prosser, WA, 24 Feb)

Matt Whiting coordinated evaluation of mechanical pruning of sweet cherries (29 Feb, Prosser, WA)

Troy Peters presented -Consumptive Use and Irrigation Water Requirements for Washington. 1 hr. Columbia River Policy Advisory Group Meeting. 45 Contacts. Lacey, WA 2/29/2012

Troy Peters presented- Water and Agriculture in the West, Now and In the Future. 1 hr. BSysE Seminar. 59 Contacts. Pullman, WA 2/17/2012

Troy Peters presented- Irrigation Management and Drip Irrigation for Lawns and Gardens. 1 hr. Master Gardeners Training. 75 Contacts. Yakima, WA 2/8/2012

Karen Lewis, BioControl in Western Orchards Workshop – Facilitator / Activity Leader, Feb 2012

Karen Lewis, Innovative Thinning Technologies Advisory Meeting – presenter, Feb 2012

Gwen Hoheisel: Best Management Practices of Spray at Practical Solution for Vineyard Pest Management Workshop, Prosser, WA.

Gwen Hoheisel: Sprayer Technology and Efficacy. GSL Hop/Grape Annual Grower Meeting, Yakima, WA.

Gwen Hoheisel: Sprayer Calibration: Pruning How and Why. Washington Association of Wine Grape Growers Annual Meeting, Convention & Trade Show, Kennewick, WA

Gwen Hoheisel: Tips for Effective Vineyard Spraying. Washington Association of Wine Grape Growers Annual Meeting, Convention & Trade Show, Kennewick, WA.

March

R.K Gallardo, 2012. Production Costs in Tree Fruit. What have we learned? Presentation given in Spanish to Kyle Mathison Orchards Employees. Wenatchee, WA. March 8.

Matt Whiting gave a presentation on mechanical harvest of sweet cherries at the British Columbia Fruit Growers Association Meeting (Summerland, BC, 2 March)

Matt Whiting coordinated a UFO orchard tour in Quincy WA (9 March)

Qin Zhang participated in NSF National Robotics Initiative Review Panel (Washington DC, March 6-7, 2012).

Qin Zhang gave a talk, titled Agricultural System Control at the 1st International Forum on Precision Agriculture, (Richland, WA, March 15-16, 2012).

April

Gwen Hoheisel: Pesticide Applicator License Basics. Practical Solutions for Vineyard Pest Management Workshop, Prosser, WA. 2012

Gwen Hoheisel: Best Management Practices of Spray. Practical Solution for Vineyard Pest Management Workshop, Prosser, WA. 2012.

Manoj Karkee visited Auvil Fruit Company to discuss potential for mechanical and automated apple harvesting, Vantage, WA (Direct Contact: 10 people). April 24, 2012

Matt Whiting hosts visiting scientist Dr. Al Gracie (University of Tasmania, Australia) for discussion on collaborations on mechanical pollination and tours local orchards and vegetable seed companies (3- 15 April)

Matt Whiting hosts UFO orchard plot tours (Prosser, Benton City, WA: 19 April)

Troy Peters: Irrigation Scheduling for Power Savings. 1 hr. Benton REA Meeting. 6 Contacts. Prosser, WA 4/27/2012

Troy Peters: Irrigation Scheduling. 2 hrs. Whatcom County Irrigation Conference. 59 Contacts. Lynden, WA 4/19/2012

Troy Peters: Revised Irrigation Water Requirements for Washington State. 1 hr. WA Dept. of Ecology Water Resources Advisory Committee. 29 Contacts. Lacey, WA 4/16/2012

Qin Zhang hosted Prof. Andrew Hashimoto of University of Hawaii at Manoa at CPAAS (Prosser, March 26-27, 2012).April

Qin Zhang, Matt Whiting, Karen Lewis, Karina Gallardo participated in International Symposium on Mechanical Harvesting & Handling Systems of Fruits and Nuts (Orlando, FL, April 1-3, 2012)

Qin Zhang and Karen Lewis participated in W1009 committee meeting (Orlando, FL, April 4-5, 2012)

Qin Zhang visited Mr. Scott Korthuis of Oxbo Corp. to discuss potential collaboration in Jatropha harvesting technology development (Seattle, WA, April 18, 2012)

Qin Zhang, Karen Lewis and Manoj Karee organized CPAAS graduate students and post-doctors touring Auvil and McDugall Orchards, (April 24, 2012)

May

Manoj Karkee hosted Samsuzana Abd Aziz, Universiti Putra Malaysia 5/31-6/1/2012

Matt Whiting attends Cherry Institute planning meeting (Yakima, WA: 23 May)

Matt Whiting hosts visitors from Chile and organizes orchard tours (Yakima Valley, WA: 7 May)

Matt Whiting provides orchard tour for Malaysian visiting scientist (Prosser, WA, 29 May

Qin Zhang and Manoj Karee participated in Hawaii biofuel feedstock research meeting, (Honolulu, HA, May 13-16, 2012)

Qin Zhang visited Shanghai Jiaotong University, China, and gave seminars in agricultural automation and horticultural mechanization (Shanghai, China, May 28-June 1, 2012).

June

Matt Whiting attends and presents results at Oregon State University cherry field day (The Dalles, OR: 5 June)

Matt Whiting coordinates orchard systems tour (Kalispell MT, 28-29 June)

Matt Whiting hosts international tour group at WSU research orchards (Prosser, WA: 15 June)

Troy Peters: Simplified Irrigation Scheduling Tools. 15 min. Potato Field Day. 120 Contacts. Othello, WA 6/28/2012

Troy Peters: Irrigation Scheduling. 1.5 hrs. Washington Association of District Employees Annual Conference. 6 contacts. Leavenworth, WA 6/12/2012

Troy Peters: Simplified Irrigation Scheduling. 30 min. Berry Growers Breakfast. 23 Contacts. Mt. Vernon, WA. 6/11/2012

Troy Peters: Irrigation of Grapes. 2 hrs. Grape Camp. 38 Contacts. Prosser, WA 6/9/2012

Troy Peters: Simplified Irrigation Scheduling. 20 minutes. Grape Grower's Breakfast. 12 Contacts. Prosser, WA 6/7/2012

Troy Peters: Irrigation Management in Washington State. 30 min. WERA1022 Annual Meeting. 16 Contacts. St. Louis, MO. 6/5/2012

Qin Zhang visited China Agricultural University, China to attend the final defenses of two jointly advised PhD students, both of whom conducted their thesis research at CPAAS (Beijing, China, June 2-5, 2012).

Qin Zhang hosted Past-President and Prof. Huanbin Liu of South China University of Science and Technology and his wife visited CPAAS (Prosser, June 6-7, 2012)

Qin Zhang was invited to give an invited keynote speech, titled Agricultural Systems and Controls at IFAC Symposium on Dynamics and Control in Agriculture and Food Processing; (Plovdiv, Bulgaria, June13-16).

July

Manoj Karkee: Presented a research project in USDA field day, Paterson, WA (Direct Contact: 60 people). July 17, 2012

Manoj Karkee,: Organized a planning meeting (Qin Zhang, Manoj Karkee and Linda Root participated) in Aurora, OR to discuss about small fruit industry need in canopy management automation area. Four researchers and seven small fruit industry representatives/growers participated in the meeting (Direct Contact: 10 people) July 23-24, 2012

Matt Whiting hosts tour group from Australia, leading a tour of new cherry orchards (Yakima Valley, WA: 23-24 July)

Matt Whiting speaks at the IFTA Summer Tour on mechanizing cherry production systems and the SSCD (Quebec, Canada, 26 July)

Troy Peters: New Irrigation Management Tools for Cranberries. 2.5 hrs. Cranberry Grower Field Day. 95 contacts. Long Beach, WA 7/27/2012

Troy Peters: Irrigation Extension Efforts at Washington State University. Seminar. 8 Contacts. Logan, UT 7/6/2012

Qin Zhang was invited to give an invited keynote speech, titled The ATOE Conference: Past, Present and Future at the 5th CIGR Symposium on Automation Technology for Off-road Equipment, (Valencia, Spain, July 7-12)

Prof. Zuoxi Zhao of South China Agricultural University visited CPAAS (Prosser, March 26-27, 2012).

Qin Zhang participated in NGWI Grape Research Brainstorming Session (Lodi, CA, July 25, 2012)

Prof. Qingting Liu of South China Agricultural University visited CPAAS (Prosser, July 27, 2012).

August

Manoj Karkee, August 27, 2012: Demonstrated the solid set canopy delivery system to a group of growers and other stakeholders, Prosser, WA (Direct Contact: 15 people).

Matt Whiting hosts meeting with industry to discuss the labor monitoring system (Prosser, WA, 22 August)

Matt Whiting coordinates demonstration of SSCD at WSU research orchards (Prosser, WA, 27 August)

Troy Peters: Simplified Irrigation Scheduling on the Go. 15 min. Onion Field Day. 112 contacts. Connell, WA 8/30/2012

Troy Peters: Revisions to the Washington Irrigation Guide (WIG); Potential Impact on Water Right and Permitting Changes. 1.5 hrs. Water Law in Washington Conference. 84 contacts. Seattle, WA 8/27/2012

Troy Peters: Update of Center Pivot Evaluation and Design (CPED) Tool. 20 min. ASABE Annual Conference. 65 contacts. Dallas, TX 8/1/2012

Qin Zhang hosted Prof. Qinghua Yang of Zhejiang University of Technology visited CPAAS (Prosser, August 3, 2012).

Qin Zhang hosted Past-President and Prof. Jin Li of Northwest A&F University of China and his wife on a visit to CPAAS (Prosser, August 10-11, 2012)

September

Gwen Hoheisel Washington State Horticultural Association Annual Meeting
Organizer of poster session. 500 people

Manoj Karkee: Met with various growers and WTFRC representatives to discuss apple harvesting technology road-map development, Prosser, WA (Direct Contact: 8 people). Sep 13, 20112

Matt Whiting coordinates meeting on labor monitoring system (Prosser, WA, 18 Sept)

Troy Peters: Irrigation Scheduler Mobile. Decreasing Water Use through Improved Irrigation Water Management. 30 min. Palouse Basin Water Summit. 183 contacts. Moscow, ID 9/27/2012

Troy Peters: Drip Irrigation for Home Lawns and Gardens. 1.5 hrs. Master Gardener Annual Meeting. 121 contacts. Pasco, WA 9/14/2012

Troy Peters: Irrigation Research and Education at Washington State University. 3 hrs. Seminar and field demonstrations for Afghan Delegation. 18 contacts. Prosser, WA 9/12/2012

October

Manoj Karkee: Curt Salisbury, Sandia National Laboratory, Albuquerque, NM 10/24/2012

Matt Whiting delivers presentation on modern orchard architecture and incorporating mechanization at International Orchard Systems Seminar (San Fernando, Chile, 23 October)

Matt Whiting gives presentation on mechanical harvest technologies for sweet cherry at International Seminar on Pedestrian Orchard Systems (Curico, Chile, 19 October)

Troy Peters: Effect of Booms on Center Pivot Infiltration and Runoff. 20 min. Potato Commission Research Review. 53 contacts. Pasco, WA11/27/2012

Troy Peters: Simplified Irrigation Scheduling on the Computer or Smart Phone. 30 min. Pacific Northwest Vegetable Growers Association Annual Meeting. 98 contacts. Kennewick, WA11/14/2012

Troy Peters: Yield and Water Use Efficiency of Deficit Irrigation on Native Spearmint. 20 min. Mint Research Commission Research Review. 13 contacts. Prosser, WA11/6/2012

Troy Peters: Update of the Washington Irrigation Guide. 1 hr. Entiat Watershed Planning Group. 10 contacts. Entiat, WA 10/3/2012

Troy Peters: Irrigation Automation in an Apple Orchard. 15 min. CPAAS Sunrise 10/2/2012 Orchard Field Day. 123 contacts. Wenatchee, WA

Hosted Prof. Baomin Li and Guanhui Teng of China Agriculturalng University visited CPAAS (Prosser, October 15-17, 2012).

November

Qin Zhang was invited to give a keynote speech, titled Precision Agriculture and Agricultural Controls at International Forum on Innovative Development Strategy for Agricultural and Biological System Engineering; (Beijing, China, November 8-10).

Troy Peters: Effect of Booms on Center Pivot Infiltration and Runoff. 20 min. Potato Commission Research Review. 53 contacts. Pasco, WA11/27/2012

Troy Peters: Simplified Irrigation Scheduling on the Computer or Smart Phone. 30 min. Pacific Northwest Vegetable Growers Association Annual Meeting. 98 contacts. Kennewick, WA11/14/2012

Troy Peters: Yield and Water Use Efficiency of Deficit Irrigation on Native Spearmint. 20 min. Mint Research Commission Research Review. 13 contacts. Prosser, WA11/6/2012

December

R.K. Gallardo, Spanish Session of the WA Horticultural Association Annual Meetings, with Victor Bueno. December 4, 2012.

R.K. Gallardo. Cost of Production of Apple, Cherry, and Pear. Presentation given at the WA Horticultural Association Annual Meetings, Yakima, WA. December 4. 2012

R.K. Gallardo. Situation of the Credit in Agriculture and Production Costs. Presentation given in Spanish at the WA Horticultural Association Annual Meetings, Yakima, WA. December 4. , 2012

Manoj Karkee, Dec 5, 2012: Presented in a Stem-free Sweet Cherry Project Information Session, Yakima, WA (Direct Contact: 45 people)

Matt Whiting coordinated the annual meeting of the SCRI team and industry (Yakima, WA, 6-7 December)

Troy Peters: Doing Research Under Irrigation. 1 hr. WSU/OSU Irrigated Agriculture Extension Meetings. 12 contacts. Prosser, WA, 12/18/2012

Troy Peters: The Effects of Deficit Irrigation on Native Spearmint. 30 min. Washington Mint Convention. 140 contacts. Pasco, WA, 12/04/2012

Gwen Hoheisel: Update on Marmorated Stink Bug and Spotted Wing Drosophila. Pesticide Education Program Recertification, Pasco, WA.

Gwen Hoheisel: Importance of Sprayer Calibration. Pesticide Education Program Recertification,Pasco, WA

Invention Disclosures

1. Zhang, Q., Du, X., Chen, D., and Scharf, P. Buffering system for improving the catching and collecting capability during fruit harvest. Filed September 9, 2011.
2. Ampatzidis Y., Pierce F., Whiting M. and Zhang Q. Labor Monitoring System for Specialty Crops. Filed February 2, 2011
3. Tan, L. (submitted, January 28). Systems and methods for collecting and accruing labor activity data under many-to-many employment relation and with distributed access.

Significant Research and Development Accomplishments

1. **Smart sprayer**
   Investigators: Francis J. Pierce, Feng Kang, Patrick Scharf, Qin Zhang
   This device is developed for practicing barrier application for cutworm control and chemical control of suckers in vineyards and high density tree fruit orchards. It applies a target recognition system detect plant trunks and control a multi-nozzle spraying system rapidly and precisely applying chemicals to obtain an adequate coverage on plant trunks. Spray efficiency tests showed that targeted applications applied higher application densities at <10% of the spray volume than commercial applications with about 65-70% of the spray hitting the target under the environmental conditions tested. The trailer targeted sprayer for cutworm control performed well and would greatly reduce insecticide application costs and open up opportunities for alternative control products that are more desirable but prohibitively expensive in larger application volumes used in conventional application systems.
   Contact: Qin Zhang (qinzhang @wsu.edu, or 509-786-9360) if interested in adopting or transferring this technology.

2. **Precision, site-specific irrigation control of an apple orchard**
   Investigators: Troy Peters, Yasin Osroosh, Qin Zhang
   This allows for site-specific and individual automatic control of various areas of an orchard. Various types of data is collected from each sub-plot within the block including soil moisture, air temperature, and canopy temperature. This data is reported back to a central control computer which analyzes the data, makes irrigation decisions, then automatically opens and closes irrigation control solenoid valves to optimally manage the irrigation for each sub-plot within the block. This setup is currently being used to test various irrigation automation algorithms.
   Contact: Troy Peters (troy_peters@wsu.edu, or 509-786-9247) if interested in adopting or transferring this technology

3. **Labor Management System**
   Investigators: Matthew Whiting, Yiannis Amatpadis, Li Tan
   We have developed a real-time labor monitoring system with the ability to track and record individual picker rate/productivity during manual harvest of specialty crops. This system utilizes existing commercial harvest equipment and integrates a digital weighing scale, RFID reader, computational unit, and cloud-based software for visualization. As fruit is dumped into a standard collection bin, the system can read simultaneously a picker's ID (RFID tag) and measure the weight of fruit. This system shows potential to improve the accuracy of picker reimbursement, fruit handling logistics, and decision making in the orchard.

4. **Hand-Held Fruit Trees Mechanical Blossom Thinner**
   Investigators: Qin Zhang, Karen Lewis, Meng Wang
   This device can be used to thin fruit tree blossom of, including but not limited to Cherry, Apple, Pear and Apricot with minor modification of the thinning head configuration. It improves thinning efficiency, reduces labor cost and improves fruit quality illustrated by trials conducted in orchards in Washington, Oregon,

Pennsylvania in US, as well in Chile..
Contact: Qin Zhang (qinzhang @wsu.edu, or 509-786-9360) if interested in adopting or transferring this technology.

5. **Knot-Tying Robotic End-effecter for High-Trellis Top Twining**
Investigators: Qin Zhang, Long He, Henry Charvet
Twining is a labor intense task in high-trellis hop production. This robotic knot-tying end-effector was developed to perform automatic knot-. Conceptual validation tests proved that the invented knot-tying end-effector could successfully tie clove hitch knots satisfactorily on trellis wires.
This technology is developed under private funding support, and is not available for technology transfer.

6. **A Remotely Controlled Bin-dog for In-orchard Bin Handling**
Investigators: Qin Zhang, Long He, Yunxiang Ye, Karen Lewis
This is a remotely controllable self-propelled bin handling platform implementable in typical Washington tree fruit orchards. It is capable of traveling in typical WA/OR tree fruit orchards; and (2) capable of placing an empty bin at target locations in the row to support efficient picking and transporting a full bin to the designated bin landing area. The developed prototype-one could accomplish the designated functionalities based on the tested results in both off-field environment and orchard environment in 2012 harvest season.

Acknowledgement of Support

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