FINAL REPORT

WTFRC Project #	TR-05-506
Project title:	PAWS2
PI:	Francis J. Pierce
Organization:	WSU Center for Precision Agricultural Systems, Prosser, WA fjpierce@wsu.edu
Cooperator(s):	Matt Whiting, *WSU Horticulture, Prosser WA 98901,* mdwhiting@wsu.edu
Contract Administrator:	Mary Lou Bricker, mdesros@wsu.edu; 509-335-7667

OBJECTIVES

1. Provide general operation budget and funding for station upgrades in support of public access to the WSU Public Agricultural Weather System (PAWS) for 2005.

Results and Discussion

The PAWS network was opened to the public in early March 2005. Registered users in 2005 exceeded 1000 compared to 120 registered users in 2004. The PAWS2 data portal was created and opened to the public in April 2005. This data portal provides direct access to raw data from PAWS for individuals and organizations that use the raw data to provide weather related information and services. Approximately 130 users registered on the PAWS2 data portal in 2005. Special arrangements were made to stream PAWS data to Vince Jones' group to support their efforts in developing pest models for tree fruit.

Approximately 37 PAWS stations required upgrades to the AgWeatherNet system and these stations were upgraded in 2005. Some stations were moved in the Northern Fruit Region and new repeaters added to expand the wireless network backbone in those areas.

New servers were installed at Pullman in the College of Agriculture, Human and Natural Resources Information Department. The goal was to move all data management and web service to a location that would not be affected by power and Internet service interruptions experienced at WSU in Prosser.

Considerable progress was made on reprogramming a new web site for AgWeatherNet. This is being done by the CAHNRS information department in Pullman. The web site is a combination of the PAWS and AgWeatherNet web sites and a beta version is operational and being evaluated.

Funding was received from the Washington State Legislature to expand AgWeatherNet. This has been an additional task for us particularly in late 2005 when the funding for this effort was released to WSU (December 7, 2005). There was no funding provided for installation or operation of new stations in 2005. New station locations are now being secured and installation is underway.

To improve performance and enhance AgWeatherNet, CPAS began the development of a replacement for the AWN100 datalogger/radio in June 2005. The AWN200 will replace the AWN100 and be used in all new stations and in all existing public stations on AgWeatherNet. The AWN200 is just being completed and testing should be complete to allow installation to proceed in late March.

The private funding for AgWeatherNet was running out and funding for 2006 was questionable. The WSU Extension and WSU Agriculture Research Center provide funding support for the first 6 months of 2006 that with CPAS staff and support would operate AgWeatherNet for the period January 1 through June 30, 2006. These funds will also support the upgrade of the existing PAWS stations to the new AWN200 during this period.

The Washington State Legislature funded the WSU AgWeatherNet Initiative in 2006 that requested permanent baseline funding of $800,000 annually to operate AgWeatherNet. These funds will be available on July 1, 2006 and efforts are underway by CPAS and WSU administration to fill positions for this effort.

CPAS received funding for a new building from the Washington State Legislature in 2005 that will provides facilities for AgWeatherNet. The building design was just recently approved by the WSU Board of Regents in March 2006. Unfortunately, the building approved is considerably less than what was proposed because of the significant rise in building costs created by the 2005 hurricanes and high fuel prices.

For some time, particularly in the last 5 months, the majority of CPAS resources are assigned to AgWeatherNet. The funding forthcoming in July from the WSU AgWeatheNet Initiative to support AgWeatherNet in the long term is a welcome sight. The efforts of the Washington Tree Fruit Industry in securing legislative funding for AgWeatherNet are recognized and very much appreciated.

FINAL REPORT

Project Title: Developing Efficient Work Platforms

PI: Tom Auvil, Dana Faubion, Karen Lewis, Clark Seavert
Organization: WTFRC, WSU, OSU
Co-PIs and affiliations: Blue Line Manufacturing, Ruben Canales,
Cooperators:
Jerry Haak, Don Weipert, , Noel Adkins, Stemilt Management, Congdon Orchards, Peter Crane, Randy Newman, John Doebler, Hans Groenke Jr., Washington Fruit and Produce, McDougal Fruit, Brad Carpenter

OBJECTIVES:

1. Determine the economic benefits of employing mechanical assist machines that reduce pruning, thinning, pheromone placement costs, and evaluate harvest efficiency in peach and cherry orchards.

2. Determine the economic benefits of employing platforms that reduce pruning, thinning, and pheromone placement in apple orchards.

3. Measure efficiencies of mechanical assisted harvest machine and platforms vs. orchard ladders and express those findings in labor per hour, bins, boxes, and pounds of fruit sold.

4. Facilitate L&I acceptance of equipment, ergonomics and safety components.

5. Assessment of worker, crew and management dynamics.

SIGNIFICANT FINDINGS:

- Efficiency and productivity of blossom thinning, green fruit thinning, limb tying, tree training, summer pruning and dormant pruning increases with the use of continuous creep, auto-steer, semi autonomous platforms.
- Degree of gained efficiency and productivity is task, orchard system and management dependent.
- Tasks that require the greatest number of ladder sets will yield the greatest efficiency gains with the platform.
- Growers want to overstaff the platforms. Limiting motion and work area per worker will negatively impact productivity.
- Uniform fruiting walls are the ideal system for platform work.
- Orchard acres adaptable to current commercial platforms are limited.
- Number of machines required to cover acreage for time sensitive tasks (thinning) will be a factor in adoption by industry.
- Machines that have built–in flexibility to physically fit into multiple planting systems and tasks should be the commercialization goal.
- All workers interviewed prefer the platform to the ladder if they can sustain hourly pay / daily pay.
- When working on a platform overall fatigue was reported to be reduced however there are situations when fatigue is a limiting factor (working above shoulder height when pruning with electric/pneumatic equipment, traveling at high speeds when pruning with loppers).
- Repetitive motion and impacts will need to be fully evaluated and mitigated.

PROGRESS SINCE 3RD QUARTER:

1) Harvest data was limited to 5 days of Pink Lady harvest using the Argilese AF-5. Productivity using the platform did not equal that of the ladder, although the conditions of the test were less than favorable.
2) Dormant pruning was conducted using the Blueline Jr. and Peterson machine at 6 orchards. Productivity was calculated on both ladders and the platform. Data was collected in linear feet per minute. Across the 6 orchards, pay scales, systems and crews, the efficiency gained with the use of platforms ranged from 30-50%.
3) Electrocoup (electric / battery-operated clippers) were evaluated during dormant pruning. Data was collected using linear feet/minute and cuts/minute protocol. Efficiencies gained/lost varied across crews and systems. Overall, the equipment was not fast enough for the employees and they choose loppers over the electrics.
4) The University of Washington – PNASH/Occupational Health Group, collected ergonomic (time and motion) data during harvest (ladders only) and during pruning (ladders and platform). This data is considered baseline and was reported in the centers NIOSH grant. The grant is currently under review.
5) Pneumatic assist pruning was attempted with Blueline Jr. – diesel engine ring failed during operations with 4 pneumatic hand prunners. Have recommended to Blueline that Jr. platforms have 4 cylinder engines (instead of two) and gear reduction wheel motors.
6) Built a self-powered, air compressor trailer that can be towed by the Blueline Jr. The trailer provides 24 ft^3/min at 175psi of oiled air for up to six tools.
7) Imported 3 types of pneumatic cutting tools to evaluate. Test is ongoing. Maintainable cut speed seems to be good ~50 –60 cuts/min. But each of the 3 types of cutting tool is cutting about 40% under manufacture specifications (1.2 inch) making commercial use nonviable without going to 240 to 250 psi line pressure (ongoing).
8) Built self-powered handgun spray trailer for the Peterson and Blueline Jr. platforms. This sprayer will be used for experimental handgun apogee applications, 2nd quarter 2006.

Fig. 1

Productivity Gained with Platforms

Time required to complete a set task (string/minute, trees/minute, etc.) when working on a platform and when working on a ladder. The data below is a composite of all data collected. Data was collected in two dimensional, fruiting wall (angled and vertical) pear and apple systems.

Task on Platform	**Productivity compared to Task on Ladder**
Harvest	-10%
Dormant Pruning	+30 -50%
Tree Training	+55%
Top String Tying	+67%
Green Fruit Thinning	+19%
Summer Pruning	+30-40%

FACTORS THAT IMPACT PRODUCTIVITY:

1) Number of employees on the platform
    Not enough work in front of the worker
    Not enough "elbow room" per worker – space constraints

2) Uniformity of fruiting wall
    Down time when trees or targets (fruit/blossoms/limbs) are missing

3) Crew dynamics
    Leadership, authority, gender/age/ability/motivation mix
    Lack of buy-in by one or more employee

4) Speed of platform movement
    Too slow and/or too fast for the specific task

5) Management style
6) Productivity expectations (output/quality)
7) Pay rate/scale/method
8) Task (thinning vs. pruning etc.)

CONTINUING REPORT

Project #: TR-05-508 **WSU Project #:** 3643-3367
Project Title: Development and Implementation of IPM Decision Aids
PI: Vincent P. Jones, Associate Entomologist
Organization: Tree Fruit Research and Extension Center
Address, phone, e-mail: 1100 N. Western Avenue, Wenatchee, WA; (509) 663-8181 ext. 273; vpjones@wsu.edu
Co-PI's and Affiliations: Gary G. Grove[1], Jay F. Brunner[2], Jerry Tangren[2], Elizabeth H. Beers[2]
[1]Irrigated Agriculture Research and Extension Center, Prosser, WA
[2]Tree Fruit Research and Extension Center
Contract Administrator: Daniel Nordquist, 509-335-9661, email: nordquist@wsu.edu

Objectives:

1. Develop a web-based program that integrates location-specific weather data (from AWN and PAWS2 or uploaded from a user's own orchard) with insect and disease models and provides management recommendations along with a simplified database for pesticide recommendations.
2. Validate and implement models for peach twig borer, *Campylomma* bug, *Lacanobia* fruitworm, white apple leafhopper, and pear psylla. Develop the management recommendations for these pests and incorporate them into the decision aid system.
3. Develop a new codling moth model using historic weather data and a validation data set.
4. Develop large-scale sampling plans for codling moth larvae that can be used for quarantine purposes.
5. Implement and validate the secondary cherry powdery mildew risk assessment model and incorporate it into the decision aid system.
6. Beta test the program with a small group of consultants to determine information needed and to optimize the user interface.

Significant Progress:

- The pesticide databases have been updated for use on the decision aid system and the Palm Pilot databases should be finished soon and on the web.
- Jerry has completely re-written our database for more reliability as the system is scaled up with new models.
- We are currently working on the *Lacanobia* model and should have the analysis by the next report.
- We are in communication with our group of consultants and should have the system on-line before the season starts.
- We have received a large amount of data for developing the codling moth model and are getting it into the correct format and pairing it with the weather data. We are also setting up to collect two extensive validation datasets this field season.
- Improved temperature algorithms for cherry mildew risk assessment have been developed and passed to the programmer. A management recommendations framework has been developed and is available online.

Objective. 1. Develop a web-based program that integrates location-specific weather data (from AWN and PAWS2 or uploaded from a user's own orchard) with insect and disease models and provides management recommendations along with a simplified database for pesticide recommendations.

The pesticide recommendation database were be updated for apples, pears, and cherries according to 2006 recommendations and have been placed on the web for use with the decision aid system. The Palm databases have not yet been updated, but will be in the next 2 weeks. The user interface for pesticide recommendations is already functional and integrated into the decision aid system, but is being changed to allow filtering the pesticide choices based on pest pressure and by conventional or non-OP type programs.

The interface for inputting non-AWN or non-PAWS2 data is complete. It is a web-based form where people can input their own site-specific weather data by use of cut and paste from excel or another spreadsheet program. This feature is currently on line and undergoing testing.

We have also received the new server and it is undergoing "burn-in" for the next two weeks before we move the system over to that server.

Jerry (our programmer) has spent the last two months going over the programming and making sure that it can be easily scaled up for later as we add more models and increase the complexity of the system. This has slowed progress and made it look like little has been accomplished. However, we hope to have it back on line in the next two weeks so that we can allow users access. Jerry has also finished a beta of the user setup page. We will be working with that over the next two weeks to get it into good shape before our beta testers need to use it this season.

Next steps. We are working with both Tim Smith (WSU Extension) and Gary Grove to be sure the recommendations and web-based models for diseases are correct. Currently, Gary has passed the apple scab and cherry powdery mildew model to Jerry and those interfaces will be worked on during the next quarter. We hope that the fireblight model and recommendations will be finished by mid-April.

Objective 2. Validate and implement models for peach twig borer, Campylomma bug, Lacanobia fruitworm, white apple leafhopper, and pear psylla. Develop the management recommendations for these pests and incorporate them into the decision aid system.

The *Campylomma* bug model is completed, and we have completed the population status and management recommendations. It should be on line in the next quarter.

Next steps. I am currently working on the *Lacanobia* model and hope to pass it to Jerry in the next 3 weeks.

Objective 3. Develop a new codling moth model using historic weather data and a validation data set.

We have received all the data and are getting it into the correct format and pairing it with weather data. We will also be collecting data from two locations this coming season for the validation data set.

Objective 4. Develop large-scale sampling plans for codling moth larvae that can be used for quarantine purposes.

We cannot begin this portion until mid-summer.

Objective 5. Validate the secondary cherry powdery mildew risk assessment model and incorporate it into the decision aid system.

The updated cherry powdery mildew model parameters have been passed to the programmer and we expect to have the beta online by the end of March. The cherry model is comprised of three components. The degree day model used to predict the exhaustion of the overwintering inoculum supply is currently being programmed . Updated temperature algorithms were passed to the programmer in mid-March. Field validation cannot begin until the season starts this coming year. Dr. Grove is arranging for the Spatial Climate Analysis Service at Oregon State University and Fox Weather, Inc. to provide contour maps of cherry powdery mildew and fire blight disease pressure.

Next Steps. The 2006 version of the cherry powdery mildew model will concentrate on regional predictions (*e.g.*, Yakima Valley, Wentachee Valley, *etc*.), with site-specific predictions coming later. An addition model component will be added when air-sampling techniques are further developed. A framework for management recommendations has also been developed and can be perused at http://fruit.wsu.edu/Models/cpm.html and http://fruit.wsu.edu/Diseases/cpmfungicides.html.

The apple scab model and associated management recommendations have been passed to the programmer.

Objective 6. Beta test the program with a small group of consultants to determine information needed and to optimize the user interface for ease of use.

We have added a red delicious bloom model and the scald model to the decision aid system in beta test, but they are not yet on-line. We have also passed the information regarding sites needed from AWN for the testing to Fran Pierce's group at CPAS, but currently do not have access to the AWN weather data.

We have tried to keep the group posted of the changes in the decision aid system by roughly monthly updates on the system modifications and will set up a meeting as soon as the new system for this year is on-line. This meeting would hopefully occur no later than the second week of April.

Next steps. This will be an ongoing dialog of testing, adding new features, re-testing, and improvement.

Budget
Project Title: Development and Implementation of IPM Decision Aids
PI: Vincent P. Jones
Project duration: 2 years
Current year: year 1
Current year request: $63,029
This is the second progress report since receiving the funding in November 2005, so we are still in year 1 budget.

Item	Year 1	Year 2	Total
Salaries[1]	32,867	34182	67,049
Benefits[2]	11782	12253	24,035
Wages	8000	8320	16,320
Benefits (11%)	880	915	1,795
Equipment[3]	4000	0	4,000
Supplies	3500	3000	6,500
Travel	2000	2000	4,000
Total	**63,029**	**60,670**	**123,699**

[1]25% FTE for Programmer (Jerry Tangren), 33% Technical Support in Wenatchee (Callie Baker), 16.7% FTE Technical Support in Prosser (Grove Technician)
[2]varies by person: Jerry Tangren 38%, Callie Baker 35%, and Grove Technician 34%.
[3]One time cost for a server at WSU-TFREC

CONTINUING PROJECT REPORT **1st Quarter YEAR 1/1**

Project Title: Mechanization Research
PI: Nagarajan Ramalingam
Organization: OSU

Objectives: Identify key new engineering practices and technologies pertaining to the tree fruit industry.

Significant Findings:

- Visited Trimble Corporation while attending a site-specific meeting with thoughts of GPS guidance within dense orchards. Trimble offered their help with integrating a self-leveling system for platform operations in sloped terrains. Key industry contacts have been identified and will be followed up to integrate self-leveling into the platform if need arises.
- Used image processing and analysis to identify the fruits in the field-of-view of the sensor. Thermal imaging cameras can be used to detect heat stress in the fruits. This is a non-contact/non-destructive method to identify fruit load. This could be a leadway for the real-time feedback for the robotic fruit harvesters.
- Attended the Tulare farm show to see the latest developments in the ag industry. Laser labeling of the fruits (instead of adhesive labeling) and the cropland sprayer heads are novel products. This sprayer is built around multiple, independent fans (4-8+) that are light weight (they are plastic), powered off tractor hydraulics, and have pressurized hydraulic nozzles arrayed around the outside of the fan. So, the air delivery of the system is separate from droplet generation, unlike the Proptec units currently in the market place. This sprayer has achieved 30% market share in Australian and New Zealand orchards and vineyards in less than a decade, according to the Australian scientists who collaborated in its development.
- Designed the over the row platform system, completed the engineering calculations, structural analysis and material selection with appropriate factors of safety.
- Performed electrostatic sprayer coverage analysis.
- Organize and participate in the orchard equipment field day in Cashmere, WA.

Key topics for next quarter:

1. Over the row platform and sprayer design and development project continuation
2. Determine the desired torque and speed for the over the row boom's translation and rotation.
3. Evaluate the changes in the center of gravity of the platform due to the width/height changes, and due to the worker's movement on the platform.
4. Sprayer research and evaluation amongst air assist, air induction, and electrostatic sprayers and comparison with airblast and tower sprayers.
5. Design of suspended spray towers with vertical zonal controls using solenoid valves for precision application of plant growth regulators and chemical thinners.
6. Evaluate the spraying system speed of travel and effects on coverage, efficacy and drift.
7. Machine vision and image processing applications for disease prediction and pitting of the fruit surface.
8. Arrange for a technical tour during ASABE Meeting in Portland, OR.

CONTINUING PROJECT REPORT

WTFRC Project # TR-05-503
Project title: Real-time Monitoring and Control for Water Management
PI: Francis J. Pierce
Organization: WSU Center for Precision Agricultural Systems, Prosser, WA 98901, fjpierce@wsu.edu
Cooperator(s): Matt Whiting, *WSU Horticulture, Prosser WA 98901,* mdwhiting@wsu.edu
Contract Administrator: Mary Lou Bricker, mdesros@wsu.edu; 509-335-7667

This report summarizes progress during 2005. A request is made to continue this project during 2006 with no additional funding to complete software and test the system.

Objectives: The proposed objectives were as follows:

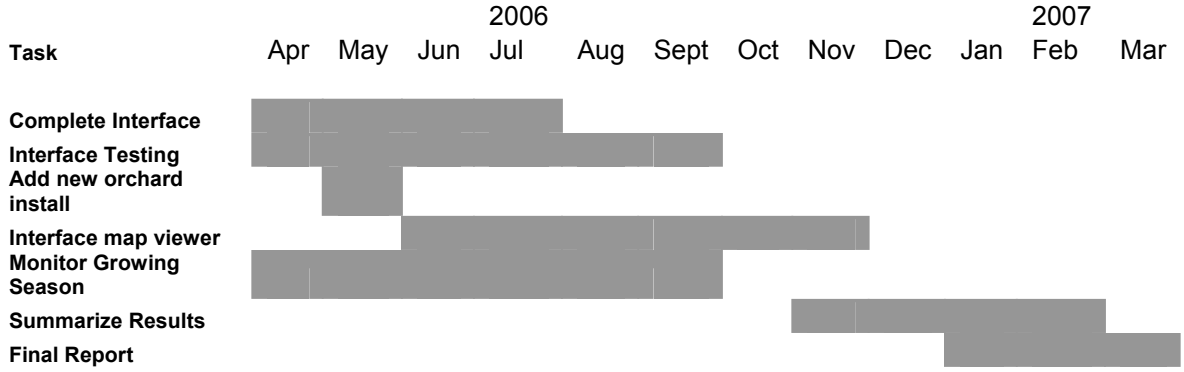
2. Develop the necessary software and additional hardware to transfer technologies for real-time irrigation and monitoring and control from annual crops to tree fruit
3. Develop GIS applications to generate irrigation "as-applied" maps and soil moisture maps for orchards that can be readily updated with real-time data.
4. Demonstrate the use of real-time irrigation monitoring and control during a field day.
5. Monitor crop stress under drought conditions for apple orchards during the growing season, using real-time monitoring of soil moisture and periodic remote sensing of canopy density and canopy temperature.
6. Integrate the Shrader FST into a real-time monitoring system.

There were deviations from the original objectives because Eileen Perry was to have worked on the GIS and remote sensing components for Objectives 2 and 4. Jim McFerson and Jim Doornink met with me in the spring of 2005 and requested that Eileen not be involved in any tree fruit funded projects. As a result, objectives 4 and that portion of objective 5 referencing objective 4 were dropped from the project. Objective 2 is now being addressed by Dr. Jose Chavez who is working part time on this project.

Goals and Activities for 2006

- Complete and test user Internet Interface for irrigation control and viewing monitoring data.
- Monitor irrigation for the 2006 growing season under irrigation control to compare with the 2005 growing season under manual control.
- Complete objective 2 by providing a map viewer in the Internet interface so that a user can display field boundaries and by clicking on a field, view displays of block and irrigation zones within blocks including current and cumulative water application depths and soil moisture contents.
- Equip another orchard block with the wireless network monitoring and control system to evaluate transferability of the technology.

Schedule of activities



Anticipated accomplishments
We expect by the end of this project period to have a fully developed and tested system for remote irrigation monitoring and control for orchards that utilize the CPAS radio on-farm network technologies.

Significant findings:

- The monitoring component of the wireless network system for real-time monitoring of irrigation systems worked consistently all season in 2005.
- Monitoring of the cherry orchard irrigation system for 2005 showed that manual operation resulted in high water application rates early in the season that greatly exceed both ET and soil water holding capacity of the root zone. Water applications later in season did not meet ET demand.
- The monitoring portion of this system was successfully demonstrated at the WSU Cherry Field Day on June 14, 2005.
- Catch can tests show that overall, average water application rates are greater than expected and more spatially variable and nozzles in a row do not reach adjacent rows but water application rates are higher in between the rows. Our calculations for water application based on nozzle specification are about 35% lower than actual water applied.
- The system for remote control of irrigation was developed whereby a user can create the desired irrigation schedule on the Internet which is transmitted via the wireless network to the Remote station which executes that schedule until another one is updated. This system, called the Orchard – Remote Irrigation Monitoring and Control System (RIMCS) has not been tested in the field since it was developed after irrigation water supplies were shut off in October 2005. The control system will be briefly tested once water is available at the Whiting cherry orchard in April 2005.
- The FST sensor had problems on the AgWeatherNet and AgFrostNet systems that may be associated with the connectors on the FST sensor or some other cause unknown to us.

Methods

The Internet user interface, the Orchard – Remote Irrigation Monitoring and Control System (O-RIMCS) will include functionality for creating an irrigation schedule table for transmission to the Remote station, the ability to calculate daily and cumulative water application rates and ET, display monitoring data in near real-time, and create summary tables and figures as desired by a user. The system will operate for multiple blocks on multiple farms. The O-RIMCS along with the data base for monitoring and control will reside on a server located at WSU-IAREC using Microsoft Web Server and SQL Server software.

We will install a monitoring and control station at another orchard in the WSU Roza Experiment Farm along with a flow meter and a pressure transducer in the main supply line and a relay board to control one or more solenoids. This station will report on the existing wireless network and be included in the 2006 evaluation of the O-RIMCS.

A map viewer will be developed so that it accepts standard formatted maps as input. Maps containing delineated fields can be input by a user and the software will execute various table and graphic functions to allow mapping of water applied per zone within each block for daily and cumulative amounts.

Results and Discussion:

Objective 1.

The development and implementation of a real-time monitoring and control for orchard irrigation was the main emphasis of this proposal. There were three components addressed in this objective including monitoring system performance, calculating a water balance, quantifying water application distribution, and controlling irrigation remotely via the Internet and are discussed below.

Monitoring Irrigation System Performance

For the 2005 growing season, a wireless monitoring network was installed at the WSU Irrigated Agriculture Research and Extension Center (IAREC) as illustrated in Figure 1. A Base SS100 radio was positioned so that it had line-of-sight connectivity with both a Remote SS100 installed at Matt Whiting's research Cherry Orchard in Block C36 at the Roza Experimental Farm and a Roamer

Figure 1. Layout of wireless network for orchard irrigation monitoring and control.

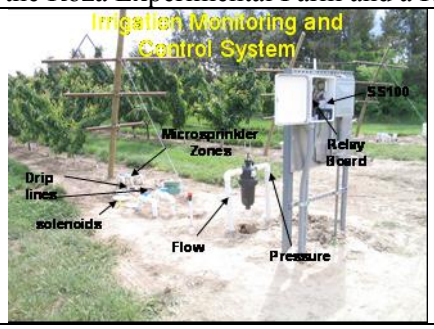


Figure 2. Layout of irrigation system and monitoring and control hardware for Dr. Whiting's research Cherry Orchard.

SS100 located at IAREC headquarters. A Remote was installed in a weatherproof enclosure powered by the same 110 V power operating the irrigation system (Figure 2). The Remote monitors a pressure sensor installed in the water supply side of the irrigation system prior to the filter and a flow meter installed after the filter. The wireless network system record flow rate and pressure and transmits these data to the Roamer every minute. A Roamer SS100 was installed in a lab at WSU-IAREC with an antenna mounted on the building roof to assure line-of-sight. The Roamer was connected to a PC operating AgFrostNet software and was connected to the Internet so that irrigation monitoring data could be stored on a remote server for Internet access. With the data base available on the Internet, a user can operate the AgFrostNet software with the PC connected to the Internet and monitor the irrigation system anywhere there is Internet access. A sample screen shot for a single irrigation event is given in Figure 3. This irrigation monitoring functionality was demonstrated at the WSU Cherry Field Day on June 14, 2005.

For the 2005 growing season, irrigation was operated by hand by Dr. Whiting's field staff using. Pressure and flow were monitored every minute throughout the growing season to provide a baseline of data on system performance without any attempt to automate control on our part. Figure 4 summarizes the irrigation water applications and ET estimated from the nearest AgWeatherNet

station. Irrigation application timing and duration were sporadic. The monitoring data show that long duration water applications early in the season created water application rates that greatly exceeded ET and likely led to leaching. These were followed by long periods of no water application where soil water was likely at deficit levels.

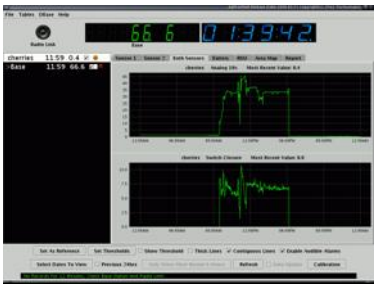


Figure 3. Screen shot of AgFrostNet monitoring irrigation water pressure and flow.

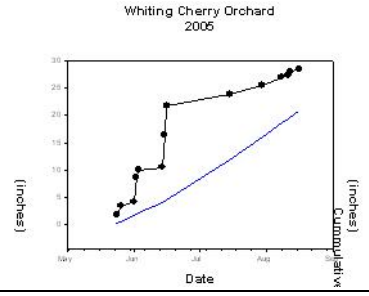


Figure 4. Water application versus ET for the cherry orchard irrigation system.

Quantifying Water Application Distribution

For this orchard irrigation design, the water application rate for these nozzles at a pressure of 25 psi is theoretically 0.59 acre-inch per hour in the row and 0.39 acre-inch per hour between the rows. Assumptions about irrigation application rates based on design are probably the best a grower will be able to do given the effort required to measure the actual application rate. However, we were curious as to how well this assumption would hold in the cherry orchard so we conducted a catch can test in mid-October that also included a single nozzle flow test using a flow meter and pressure transducer installed just prior to the nozzle (Figures 5 and 6). The catch can test included 110 cans spaced 2.67 feet apart. The single nozzle flow meter was monitored using the wireless network providing one-minute flow data during the test. Three tests were conducted: one with the full irrigation system, one with only one row on, and one with a only single nozzle on. The results show that water application rate is varies spatially with the highest rates occurring between the rows (Figure 7a). The peak application occurred where a post in the row deflected water into the nearest catch cans. The single row test show that without overlap, the water application distribution is nearly as expected except that water distribution within the row varies because water is deflected off the trees (Figure 7b). The single nozzle application looks as expected with a maximum application rate near the nozzle (Figure 7c). The average water application rate in the full test average 0.83 acre-inch per hour and ranged from 0.44 to 1.52 acre-inch per hour, a more variable and generally higher rate than that calculated from nozzle specifications. These tests show that overall, average water application rates are greater than expected and more spatially variable and nozzles in a row do not reach adjacent rows but water application rates are higher in between the rows. Our calculations for water application based on nozzle specification are about 35% lower than actual water applied.

Figure 5. Catch can test arrangement in the cherry orchard.

Figure 6. Flow and pressure meter test on a single nozzle.

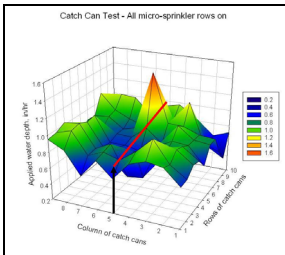
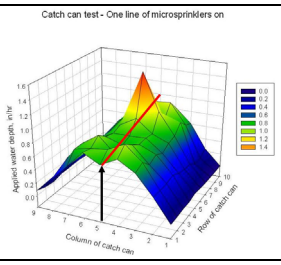
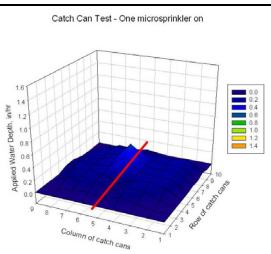
		

Figure 7. Water application pattern for a. the full array of microsprinklers at the Whiting cherry orchard.	b. for a single row of microsprinklers at the Whiting cherry orchard.	**c.** for a single microsprinkler nozzle of at the Whiting cherry orchard.

Remote Irrigation Control

The initial monitoring configuration provides real-time monitoring of an irrigation zone but no control. To achieve irrigation control, a relay board was installed in the enclosure and wired to each of the five solenoid valves installed by Dr. Whiting to control the three irrigation zones for microsprinklers within the cherry block and two drip lines, one installed on each side of each cherry row (Figure 2). The intent was to remotely control solenoids using the relay board to switch them on or off as programmed to meet the irrigation requirements imposed by Dr. Whiting. The irrigation schedule for this orchard block involved turning the irrigation system on a given day for a set time period. The plan was to automate the relay board using an irrigation schedule stored on the SS100 Remote that would control each solenoid independently. The irrigation schedule was designed to provide the on time control for each day of the week for a given start time and a duration of an irrigation event. Because the SS100 did not have adequate memory, we revised the SS100 by changing the data logger portion to include a new microprocessor and a flash memory card and added new firmware that would accommodate new functionality for irrigation scheduling. The resulting new SS100a has four times the processing speed, more memory in the process, and can accept up to a 4 Gbyte flash card for on-board storage. Firmware changes also allow for the Roamer to send irrigation schedule updates to the Remote via the wireless network and to execute the irrigation schedule. The SS100a radios were installed to replace the SS100 radios.

To facilitate remote update of the irrigation schedule via the Internet, we created an interface (called the Orchard - Remote Irrigation Monitoring and Control System (RIMCS)) to allow a user to create a new or edit an existing irrigation schedule table. After logging in to a secure web site (imcs.prosser.wsu.edu), a user is guided through the process of creating an irrigation schedule table from scratch or by modifying a previous schedule. Operationally, all previously created schedules are saved on the server and available for review or modification at any time by the user. The last table created on the ORIMCS server is available for transfer to the target Remote via a Roamer connected to the Internet. Basically, the irrigation schedule remote update process works as follows. The PC connected to the Roamer and the Internet automatically updates the remote data base on flow and pressure at a time frame selected by the user (default is one minute). At each update time, the ORIMCS data base is checked to see if a new table is available for transfer. When a new schedule is found, it is transmitted from the Roamer to the Remote which ultimately reports back to the server confirming that the schedule was updated. A confirmation data and time is recorded in the table history so that a remote user can be assured that the new schedule was installed at the Remote. The Remote executes the schedule turning each solenoid on as prescribed by the irrigation schedule.

Other functionality intended for the Orchard-RIMCS is to allow the user to view system performance and system summaries on the Internet but this component is not completed at this time. Currently, functionality to calculate water application amounts and ET by date and cumulatively are built into AgWeatherNet which allows the user to select the water application or ET tables or a plot of

cumulative ET and cumulative water application. The flow and pressure data are obtained from the O-RIMCS server holding the data from the network. The plan is to move this functionality to the O-RIMCS user interface and add graphic capabilities to plot flow and pressure and other parameters that might be available on the sensor network in the future.

Objective 3.
The irrigation monitoring functionality of this system was demonstrated at the WSU Cherry Field Day on June 14, 2005. A brochure was handed out to the attendees and a live demonstration was presented showing the system monitoring on a laptop connected to a Roamer in the field.

Objective 5.
Our efforts continued during 2005 to integrate the FST sensor into AgWeatherNet. We encounter problems with the FST sensor that were not observed by Dr. Shrader's team. The AWN100 samples the FST sensor every 10 seconds and integrates the measurements into a 15 minute average that is reported on the AgWeatherNet system. The system worked for some installations but failed in others. We did an extensive evaluation of one FST sensor independent of the AWN100 unit and found that there were problems with the connector used in the FST sensor. We wrote a report on our findings and sent that to the Tree Fruit Commission and to Dr. Sharder. We also worked with Jim Doornink in assessing the FST sensor on the AgFrostNet system. I do not have details on his experiments but was told by Jim that he too found problems with the FST sensor. Since we did not have access to the technologies supporting the FST sensor, there is nothing we could do here to remedy the situation at our end. In theory, the FST sensor, like sensors with similar outputs, should work on the AWN100 and the SS100.

Budget: Provide a detailed list including salary and wage costs with benefits, equipment, supplies, travel, and miscellaneous (crop purchase, etc.). Restate the budget from prior and future year(s) and highlight the current year request. Indicate support from other funding sources, including amount and status of funds (contingent or guaranteed).

BUDGET - ***NO ADDITIONAL FUNDS REQUESTED FOR 2006***

Project Title: Real-time Monitoring and Control for Water Management
PI: Fran Pierce
Project duration: 2005
Current year: 2005
Project total (1 year): $60,448
Current year request: $0

Item	**Year 1 (2005)**	**Year 2 (2006)**
Salaries	24,837	0
Benefits	7,581	0
Time Slip Wages	5,000	0
Benefits (16%)	800	0
Equipment	10,000	0
Data collection and processing	5,000	0
Travel	1,000	0
Miscellaneous	6,230	0

CONTINUING PROJECT REPORT

Project Title: Technology Roadmap

PI: Nick Ashmore, Ashmore and Associates, Inc.
400 North Capitol Street, N. W.
Suite 363
Washington, D. C. 20001
(202) 783 6511; Fax (703) 764 0910

RE: Activities Report, February 2006

Activities in February 2006 included, but were not limited to, the following:

- Worked with Initiative leaders and with U. S. Apple to refine appropriations requests for this budget/appropriations cycle;
- Monitored developments in Congress and in the Administration regarding the President's budget requests and their implications for industry research priorities;
- Continued to encourage completion of the White Paper with an Executive Summary for the genome/genetics/breeding initiative;
- Worked with Initiative leaders and U.S. Apple staff to identify and explore options to react to decisions made regarding sequencing of the peach genome;
- Continued to explore options that could lead to increased collaboration with other interest groups on actions that will further strengthen Roadmap priorities.

NEW PROJECT PROPOSAL **PROPOSED DURATION:** One Year

Project Title: Can Spray Deposition/Retention Agents Increase Efficacy?
PI: Allan Felsot
Organization: Washington State University, Department of Entomology, 509-372-7365
afelsot@tricity.wsu.edu

Contract Administrator: Barb Smith; 509-355-5504; niehoff@wsu.edu

Justification:

Countries importing apples from the Pacific Northwest are demanding unblemished fruit and virtually no pesticide residues. Particularly troubling are the recent findings of codling moth in shipments to Taiwan, a country that has ironically also been concerned about pesticide residues. Given the number of apples harvested and shipped and the wide area of production, probability theory alone would predict that not every insecticide treated apple would provide perfect control of codling moth injury. Despite the logic of such an argument, our import markets expect "perfection". Such perfection could probably be achieved, but at great cost to growers. For example, number of cover sprays could be increased, especially of the new reduced risk insecticides where consumer dietary intake is not of concern to EPA. Such a strategy, however, is a disadvantage to growers from an economic perspective. From a perspective of sustaining the usability of technology, increased number of cover sprays of codling moth insecticides invites a quick evolution of resistance.

One unexplored area for tree fruit protection is the role of adjuvant technology in increasing deposition and coverage of insecticides within the canopy and especially on fruit. While a plethora of studies abound regarding the relationships between enhanced herbicide efficacy and use of adjuvants, little attention has been given to the role of adjuvants in increasing deposition of insecticides on the smooth surfaces of pome fruit and on the resulting biological activity.

In previously funded research from the WTFRC Technology Committee, I've reported that spray deposition on the underside of leaves is very high, and the residues are persistent and highly pesticidal to neonate codling moth larvae for at least 21 days after application. On the other hand, I reported that deposition on apples is much poorer than on leaves when residues on a surface area basis are compared. This difference is more pronounced for smaller apples than for larger apples. Laboratory bioassays with apples also show much lower and less persistent control of codling moth larvae than what is observed on leaves. The differences between apples and leaves with regard to residues and efficacy could be caused by the lack of retention of spray deposits on the different surfaces. For example, the undersides of leaves have a high density of waxy hairs while the apple surface is very smooth. Sprays probably adsorb better to the large area of "hairy" surfaces better than to the smoother surfaces. This hypothesis leads to the question of whether commercial adjuvants can improve the deposition and retention of pesticide sprays on apples and consequently improve pest control.

During the past two growing seasons, Wilbur-Ellis has funded research to determine if one of its deposition/retention agents (specifically the product In-Place) can reduce drift from airblast sprayers as it has been shown to do for aerial and ground-boom sprayers. We did show significant reduction in out-of-orchard drift from use of this agent in tank mixes with Assail and with Imidan (Figure 1). However, we began to wonder where the pesticide actually goes and have hypothesized increased deposition in the canopy. If this hypothesis has merit, than perhaps deposition/retention agents can improve control of codling moths on apples. As insecticide use shifts from the comparatively larger per acre application rates of Imidan and Guthion to the much lower rates of Assail and Intreprid, deposition and retention efficiency could enhance success of the emerging IPM strategies for using the reduced risk insecticides.

Objective: The goal of this project is to improve deposition and retention of insecticide residues on apples so that codling moth control is enhanced. This goal should help fruit exporters ensure high quality fruit with a lowered risk of detecting codling moth damage or the presence of larvae. Progress toward this goal will be met by two objectives.

1. Determine if a deposition and retention agent adjuvant can increase the deposition and coverage of pesticide sprays on fruit.
2. Determine if a deposition and retention agent enhances and prolongs pesticidal activity against codling moth neonates.

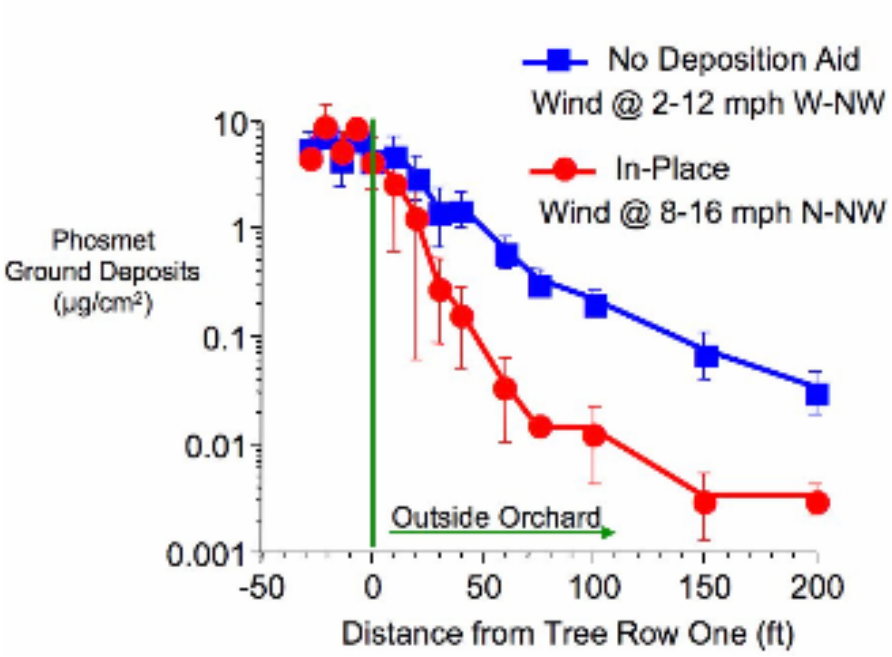


Figure 1. The influence of In-Place adjuvant on the ground deposition of phosmet (Imidan) residues applied by airblast sprayer, 09/02/04. Vertical lines about each data point represent 95% confidence intervals. The highly significant reduction in out of orchard drift led to the hypothesis that the spray not moving off-target may be depositing on the apples.

Methods:

A field experiment will be set up at the Klingele farm near Prosser, WA. A five-acre block of 'Gala' apples has been used at this farm since 2000 to carry out other WTFRC and EPA funded studies of spray drift and residues on foliage and apples. Each row of the block has 80 trees spaced about 6-7 feet apart. The block will be divided into two parts with 30 trees x 10 rows assigned to one of two treatments: insecticide spray with In-Place deposition/retention aid adjuvant and an insecticide spray without adjuvant. Guthion and Assail will be studied. Two cover sprays will be made by airblast sprayer to coincide with each codling moth generation. Guthion will be applied for the first cover spray, and Assail will be applied for the second cover spray. The insecticides will first be applied to one 300-tree plot without In-Place, and then the other 300-tree plot will be sprayed with In-Place added to the tank.

The sampling plan will consist of collecting apples and foliage from each of 15 randomly chosen trees immediately after application and again 10 and 20 days later. From each tree, seven samples of apples and surrounding foliage will be collected and composited in a plastic bag. Each of the 15 composited samples will be considered independent replicates of the two treatments.

Insecticide residues from each cover spray will be analyzed from each of the 15 replicate samples taken from each treatment. Leaf disks (1 cm^2) will be punched from the leaves of each tree and then extracted with a 2:1 acetone:water solution by shaking for 5 minutes. This quick solvent wash technique is a surrogate for insecticide deposits bioavailable to a crawling larva.

Each collected apple will be weighed and two perpendicular diameters determined to estimate surface area. Apples will be macerated in dry ice and then extracted using the USDA QuEChERS method (Schenck and Hobb 2004) that has been validated for use in the WSU Food and Environmental Quality Lab. Residues from leaves and apples will be expressed on a mass per surface area basis for comparison to the previously estimated LC50 and LC95 endpoints.

Companion sets of leaf punches and apples will also be bioassayed with neonate codling moths. Eggs will be obtained from the USDA lab in Wapato, WA. When the eggs hatch, five larvae will be placed on replicates of field-treated leaves and on apples. For leaves, individual larval mortality or a moribund state will be counted relative to the total number of larvae observed and the data then changed to percentage mortality. For apples, entry holes and stings will be counted. Percentage reduction in entry holes will be calculated relative to injury on untreated control apples.

Statistical analyses will test the hypothesis that the In-Place adjuvant increases insecticide deposition or retention and biological efficacy. Residues and larval mortality/reduction in entry hole data will be analyzed for conformity to a normal distribution. If the data are distributed normally, a T-Test will be used to compare differences in residue quantity or efficacy. If the data are not normally distributed, then the Mann-Whitney U Test, a non-parametric procedure, will be applied.

Proposed Schedule of Accomplishments:

The assume project start date is April 2006.

Task	**1st Qtr**	**2nd Qtr**	**3rd Qtr**	**4th Qtr**
First Cover Spray				
Sample Collection				
Second Cover Spray				
Sample Collection				
Sample Processing				
Sample Analysis				
Bioassays				
Statistical Analysis & Final Report				

Literature Review:

Spray adjuvants known as deposition and retention agents are commonly added to herbicide tank mixes to improve efficacy against weeds. In addition to improved spray residue coverage and efficacy, these adjuvants are also commonly marketed as drift retardants. Use of deposition and retention agents is more limited for disease and insect control, perhaps because research on the relationship between residues and efficacy has been given less attention than for weed control. The influence of deposition and retention agents in tree fruit pest management has been neglected judging by the lack of published papers or reports addressing this issue. In short, tree fruit growers have very limited information about whether these types of adjuvants are truly effective or just a waste of money.

Spray adjuvants typically function to reduce the surface tension of water and enhance droplet spreading by reducing the contact angle between a leaf surface and the spray droplet immediately after deposition (Felsot 2001). Some spray adjuvants are especially marketed to improve deposition and retention of sprays. Research has shown that adjuvants can increase retention of spray droplets on smooth surfaces but are not as effective on “hairy” surfaces. For example, several different adjuvants increased retention of sprays on the smooth leaves of peas but were no more effective than

water alone when the rougher surfaces of cucumber leaves were sprayed (Gaskin et al. 2000).

Although adjuvants can change spray quality (i.e., the distribution of spray particle sizes), the increased deposition and retention on plant surfaces seems unrelated to this function (Holloway et al. 2000). Rather, the relationship between deposition efficiency and adjuvant presence seems better correlated with the surface tension of the spray liquid. Although the research on adjuvants has focused on foliar deposition and been oriented to herbicidal efficacy, the fact that deposition of sprays is enhanced on smooth surfaces may have great importance for pest control on fruit. Indeed, our past studies show very good coverage of a fluorescent tracer on the comparatively hairy undersides of apple leaves but gaps in coverage on the smooth surface of the fruit.

In-Place deposition/retention aid is manufactured by Wilbur Ellis. According to the product technical data its principal functioning agents are amine salts of organic acids, aromatic acids, and aromatic and aliphatic petroleum distillates (http://www.wilbur-ellis.com/WC/inplace.htm). The adjuvant purportedly forms micelles with a predominantly positive charge when added to water. Micelle formation itself decreases surface tension, but research shows that spray quality, as measured by the volume median diameter of spray particles, is not altered by In-Place (Jones 2002). Nevertheless aerial application trials using In-Place showed that it reduced drift. One hypothesis that can explain this observation is that the micelles incorporate the active ingredient. Bigger spray droplets can contain more micelles than smaller spray droplets and therefore more active ingredient tends to stay closer to the target when emitted from the nozzles. This hypothesis raises the question of whether the actual coverage on the target would be augmented because less of the active ingredient is lost off-target.

Micelles containing active ingredient have also been reported to decrease penetration through biological membranes such as the epidermal cells of a leaf or fruit (Van Valkenburg 1982). This property could be important for improving efficacy of insecticide deposits on fruit. Conventional organophosphorus insecticides like Guthion or Imidan tend to stay on the surface of the fruit over time rather than diffuse through the epidermal layer (Belanger et al. 1991). However, Assail has exhibited translaminar movement across leaf surfaces (Buckholz and Nauen 2001), and presumably it can penetrate the fruit peel and translocate into the pulp. Such diffusion may dilute Assail residues on apple surfaces and thus result in less active ingredient per unit of surface area. Deposit structure (the pattern of treated and untreated areas) of a spray on a surface is critical to efficiently causing toxicity of a mobile pest (Ebert and Hall 1999). Thus, any adjuvant that would keep the deposits intact on the surface rather than allow diffusion away from the surface hypothetically has the potential to enhance pest control efficacy.

References:

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Buckholz, A. and R. Nauen. 2001. Translocation and translaminar bioavailabilitiy of two neonicotinoid insecticides after foliar application to cabbage and cotton. Pest Management Science **58**: 10-16.

Ebert, T. A. and F. R. Hall. 1999. Deposit structure effects on insecticide bioassays. J. Econ. Entomol. **92**(5): 1007-1013.

Felsot, A. 2001. Spreaders stickers. Encyclopedia of Plant Pathology, vol. 2. O. C. Maloy and T. D. Murray, eds., John Wiley & Sons, Inc., New York. pp. 962-963.

Gaskin, R. E., R. J. Murray, H. Krishna and A. Carpenter. 2000. Effect of adjuvants on the retention of insecticide spray on cucumber and pea foliage. New Zealand Plant Protection **53**: 355-359.

Holloway, P. J., M. C. B. Ellis, D. A. Webb, N. M. Western, C. R. Tuck, A. L. Hayes and P. C. H. Miller. 2000. Effects of some agricultural tank-mix adjuvants on the deposition efficiency of aqueous sprays on foliage. Crop Protection **19**: 27-37.

Jones, M. 2002. The use of adjuvants for reducing spray drift. University of Queensland, School of Agronomy and Horticulture, http://www.aghort.uq.edu.au/cpas/info-adjuvant-reducingdrift.html.

Schenck, F. J. and J. E. Hobbe. 2004. Evaluation of the quick, easy, cheap, effective, rugged, and safe (QuEChERS) approach to pesticide residue analysis. Bull. Environ. Contam. Toxicol. **73**: 24-30.

Van Valkenburg, J. W. 1982. Terminology, classification, and chemistry. In *Adjuvants for Herbicides*, Weed Science Society of America, Champaign, IL. pp. 1-9.

Budget: (Note: The budget was submitted to CAHNRS for review and approved by Mary Lou Bricker, 12/13/05)

Project Title: Can Spray Deposition/Retention Agents Increase Efficacy?
PI: Allan Felsot
Project Duration: 2006 (One Year)
Current year: 2005
Project Total (one year): $24,233

Item	Year 1 (2006)
Salary (6 months @ 0.5 FTE)	$9,060
Benefits Salary (@59%)	5,345
Wages	5160
Benefits Wages (@11%)	568
Supplies	3,500
Travel	600
Total	**$24,233**

Budget Justification

Salary: Support for six months of a 50%-time technical assistant is requested. This person has been employed at the FEQL for over 10 years and is familiar with all operations in the lab. For the last several years, I have received no state technical support for my research projects and must fund all personnel and lab activities from grants and contracts.

Wages: A temporary hourly wage worker is requested to help with field work, prepare samples for analysis, and provide lab clean up.

Supplies: I've estimated that about 400 samples will be analyzed for this project. The supplies budget reflects the need for gas chromatography (GC) replacement parts (GC columns, detector replacement, glass injection liners, autosampler syringes), extraction solvents (acetonitrile and acetone), and replacement glassware. Compressed gases required include liquid carbon dioxide (for making dry ice to macerate apple samples), and compressed air and ultra high purity nitrogen and helium to run the GC.

Travel: The funding will be used to reimburse round trip travel mileage to the field site.

NEW PROJECT PROPOSAL **PROPOSED DURATION: 2 YEARS**

Project Title: Simple, Cheap Apple Maturity Estimation for Field Use
PI: John Fellman
Organization: Dept. of Horticulture/Landscape Architecture,
Washington State University, Pullman WA 99164-6414
509-335-3454. email: fellman@wsu.edu

Other Personnel: D. Scott Mattinson, Associate in Research
Doctoral Student, WSU, Dept. of Horticulture/Landscape Architecture
Undergraduate Students, Work-Study and Time slip Employees
WSU-Pullman Postharvest Lab

Co-operators: James Mattheis, USDA ARS Wenatchee

Contract Administrator: Mary Lou Bricker
WSU Ag Res. Ctr.
Pullman, WA 99164-6240
Phone: 509-335-7667
Email: mdesros@wsu.edu

Duration: July 2006 to July 2008

Abstract:

Work described here proposed to prove and subsequently develop for field use a "novel" harvest maturity indicator for apple fruits. Preliminary observations seemed to indicate that a "bug-sting" causing a system one ethylene response creates a small red-halo around the sting punctureTherefore, at the precise time of harvest the red-halos then disappear or no longer form a red color around the sting hole. The relationship involves a visual indication at the fruit epidermal level that fruit maturity is in a system one ethylene response or a system two ethylene response, indicating onset of climacteric ripening and advancing harvest maturity. Preliminary experiments at the WSU postharvest laboratory indicate definite response difference between pre-climacteric fruit and climacteric fruit. Specifically our laboratory will determine the number of fruit necessary to obtain adequate data sets, providing reasonable counts on red-halo formation. The fruit material will be both Rome and Red Delicious apples.

Background/rationale

Ethylene mediated responses occur in all plants. A unique feature to climacteric fruits, which continue to ripen after detatchment from the mother plant is the existence of two different ethylene-producing systems. In climacteric fruits, ripening is characterized by **ethylene production**, apparently an autocatalytic process The concept of two systems for ethylene production was introduced in 1972.

System 1 is the ethylene production system common to climacteric and non-climacteric fruits—operates in climacteric fruits until the onset of ripening. System 1 ethylene production is usually in response to signals received by the plant that involve flowering, growth, development, and responses to biological as well as non-biological stress. In apples, responses to puncture wounds before the apple skin becomes loaded with red pigments usually results in a "red-halo" (Figure 1a) surrounding the wound. This is due to the system 1 ethylene-induced response.

System 2 is the autocatalytic portion of ethylene manufacture in climacteric fruits, induced when things are "ready to ripen" and the continuous synthesis of ethylene ensures that apples, once induced to ripen, continue to ripen. Once system 2 ethylene production starts, storage operators can use various techniques to lower the ripening rate thus extending the storage and marketing life of the crop.

Preliminary studies conducted at WSU-Pullman have demonstrated the feasibility of harvest maturity monitoring using the incidence of red halo formation in a controlled situation. Fruit can be bagged early in the growing season to inhibit pigment formation until the bag is removed, exposing apple skin to the radiance(natural sunlight or artificial light) necessary for red pigment synthesis to occur. If apples have not entered into system 2 ethylene production, wounding of the skin induces the red halo to form. Alternately, if climacteric ripening has already started, no halo will be seen, rather a complete coloration of the apple skin is observed (Figure 1b).

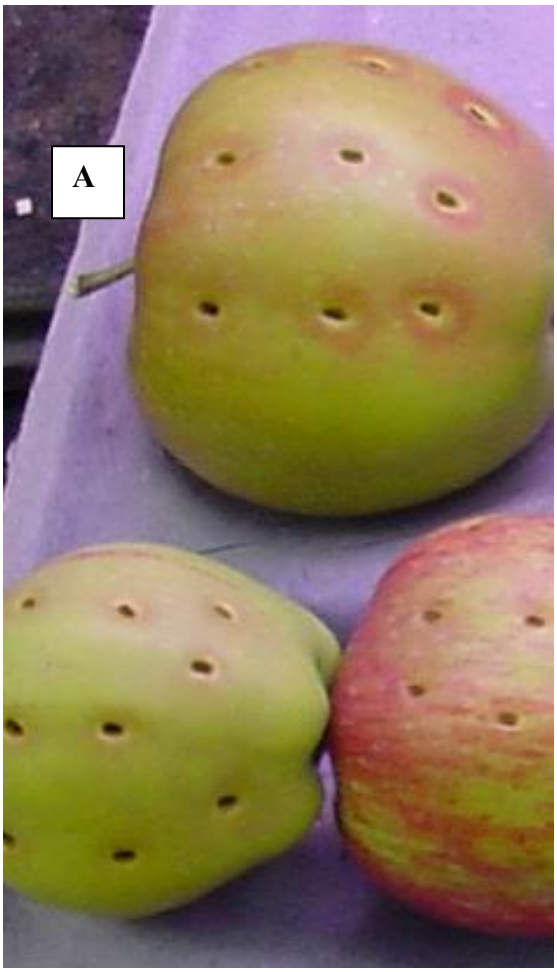


Figure 1. The red-halo is shown in (A), the top apple is Rome and the bottom apple is 'Redchief' in the preclimacteric(System 1 ethylene only) state at September 8th. After system 2 ethylene production occurs, the fruit have entered the climacteric ripening phase, by October 19 in this study, the red-halo is not forming due to the background color changing from green to red quickly (B) top fruit is 'Rome'; bottom fruit is 'Redchief'


B

Objectives:

1) Specifically our laboratory will determine the number of fruit necessary to obtain adequate data sets, providing reasonable counts on red-halo formation. For our first Study, the fruit material will be both Rome and Red Delicious apples.
2) In order to assay 'red-halo' formation, fruit shall be bagged early in the growing season. However, the exact time of bagging should be determined more precisely. Previous work seems to indicate that bagging early in the growing season around August 1st is optimal?
3) The typical fruit quality parameters will be assayed including firmness, brix, titratable acidity, color, respiration, ethylene production, and volatile aroma.
4) The most important physiological parameter, internal ethylene concentration (IEC) will be the absolute measure of System 2 ethylene onset and climacteric respiratory response.

Methods:

Red Halo Formation: A "novel" assay was developed in the WSU postharvest lab by using a one hole puncture and assessment of red-halo formation on apple fruit. Each fruit will be punctured approx. 9 times and placed under two sets of lamps at approx. 6 inches overhead. The lamps will be 1.22 m dual outlet banks, one lamp will be a 40-W cool-white deluxe fluorescent bulb and one 40-W fluorescent UV lamp. These lamps have previously been reported to produce UV-A, UV-B, and visible light with a apple surface temperature around 25^{o}C (Rudell, et al., 2002). The red-halo will be scored after light exposure between 48-72 hours.
IEC, Quality, Color assessment. The Washington State University Postharvest Laboratory will perform weekly assessments of internal ethylene concentration, fruit firmness, brix, and titratable acidity, as well as color.
Respiration and Ethylen eproduction: The WSU posharvest laboratory will ascertain the weekly carbon dioxide and ethylene production as a necessary measure of fruit climacteric.
Volatile Aroma Assay: During the assessment of fruit quality, apple juice will be stored at 0^{o}C and analyzed for volatile aroma using previously developed methods in our laboratory. The principal method is solid phase micro-extraction (SPME) coupled with gas chromatography and mass spectrometry.

Preliminary observations:

Red-Halo Observations

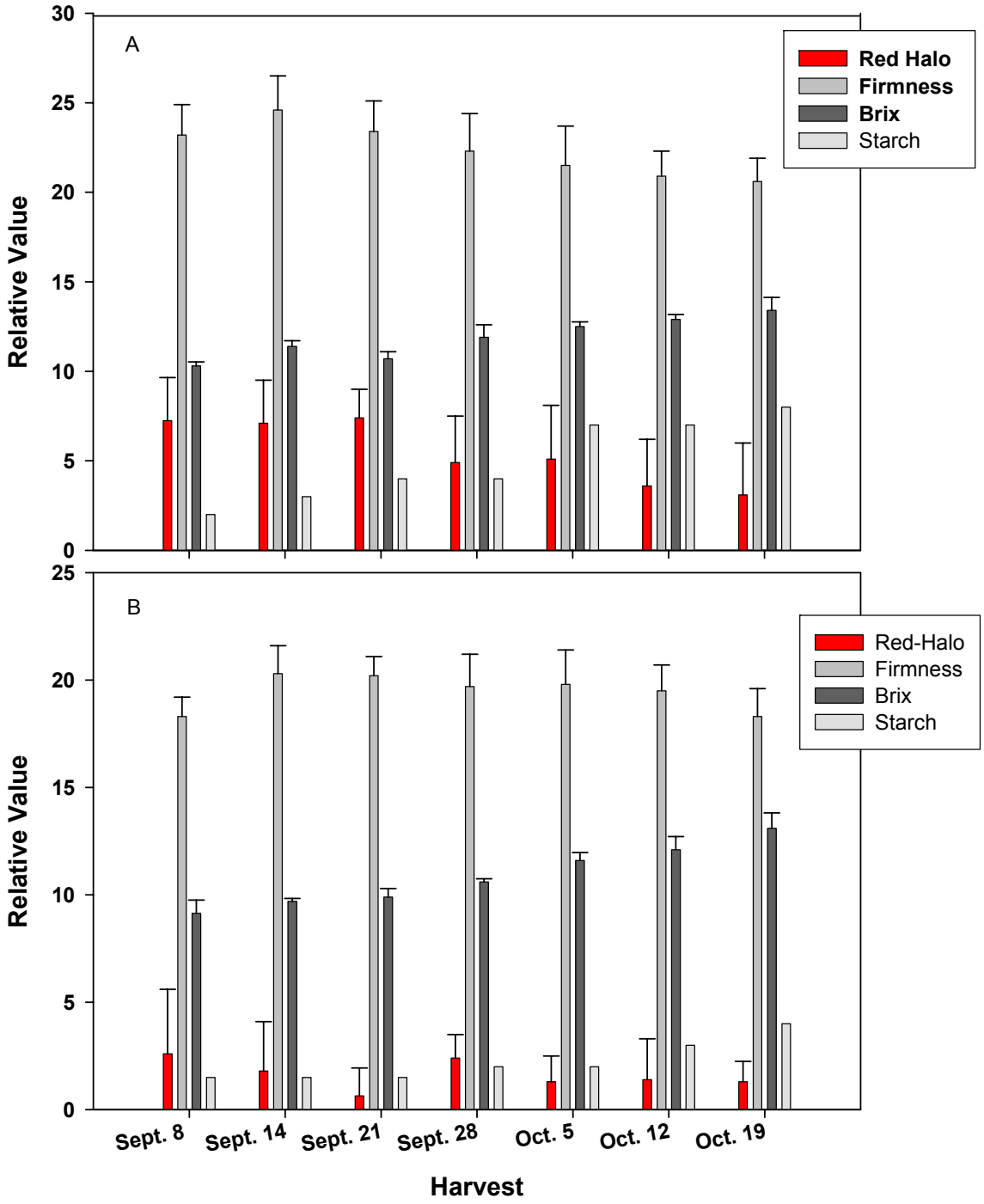
1) The concept of a "red halo" formation is depicted in figure 1.
2) The red-halo forms early with immature fruit maturity (Figure 1).
3) The red-halo forms very well in "non-striped" red fruit such as Rome apples, and to a marginal degree in "striped" fruit such as 'Red Chief Delicious'. (Figure 1).
4) The red-halo, in fact, stops forming at or around the time of climacteric onset. (Figure 1).
5) The red-halo test is rather simple and is quantitative.

Red Halo Relationships with Fruit Quality

1) The red-halo seems to form at a high percentage in the pre-climacteric state in Rome apples (Fig. 2A), but to a lesser degree in Red Delicious apples (Fig. 2B).
2) During the time of fruit climacteric, by October 19th the red halo decreased, but not dramatically in relationship with IEC (Figure 2A,B).

3) Rome apples showed a slight decrease between October 12th to 19th, while Red Delicious apples showed nearly zero decrease in red halo formation during this period (Figure 2A,B).
4) During fruit maturation between October 5-12th, some of the halos formed were actually green! This result may indicates a non-uniform assessment of the red halo score. These types of halos may be biochemically equivalent to no red halo.
5) The red-halo score does in fact decrease more than other fruit quality attributes such as firmness, brix, and starch through maturation (Figure 3A), especially in Rome apples. Red Delicious apples did not show a very dramatic change over harvest maturity compared to firmness, brix, and starch (Figure 3B).

Conceptually, the red halo test might be a constitutively expressed parameter, which may show dramatic changes similar to fruit volatiles. The major ester, 2-methyl butyl acetate is detectable well before apple climacteric, similar to the red halo, yet shows a dramatic burst at climacteric ripening(Figure 4).


A
B
Red Halo
Firmness
Brix
Starch
Red-Halo
Relative Value
Harvest
Sept. 8
Sept. 14
Sept. 21
Sept. 28
Oct. 5
Oct. 12
Oct. 19

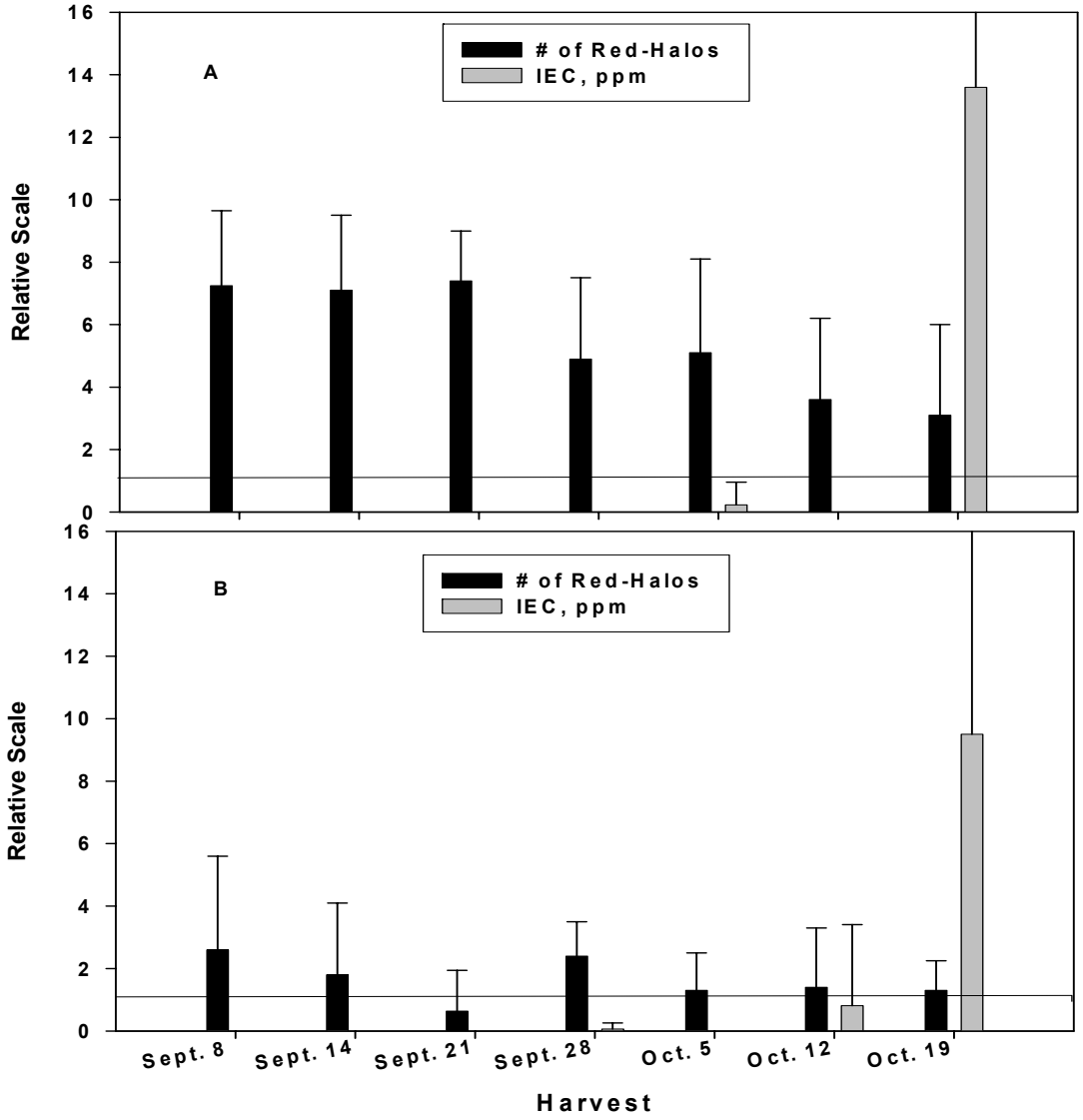


Figure 2. The number of red halos formed on the fruit surfaces which had been previously blocked from sunlight then assayed at harvest. The amount of internal ethylene is also shown as measured in (A) Rome apples and (B) Red Delicious apples.

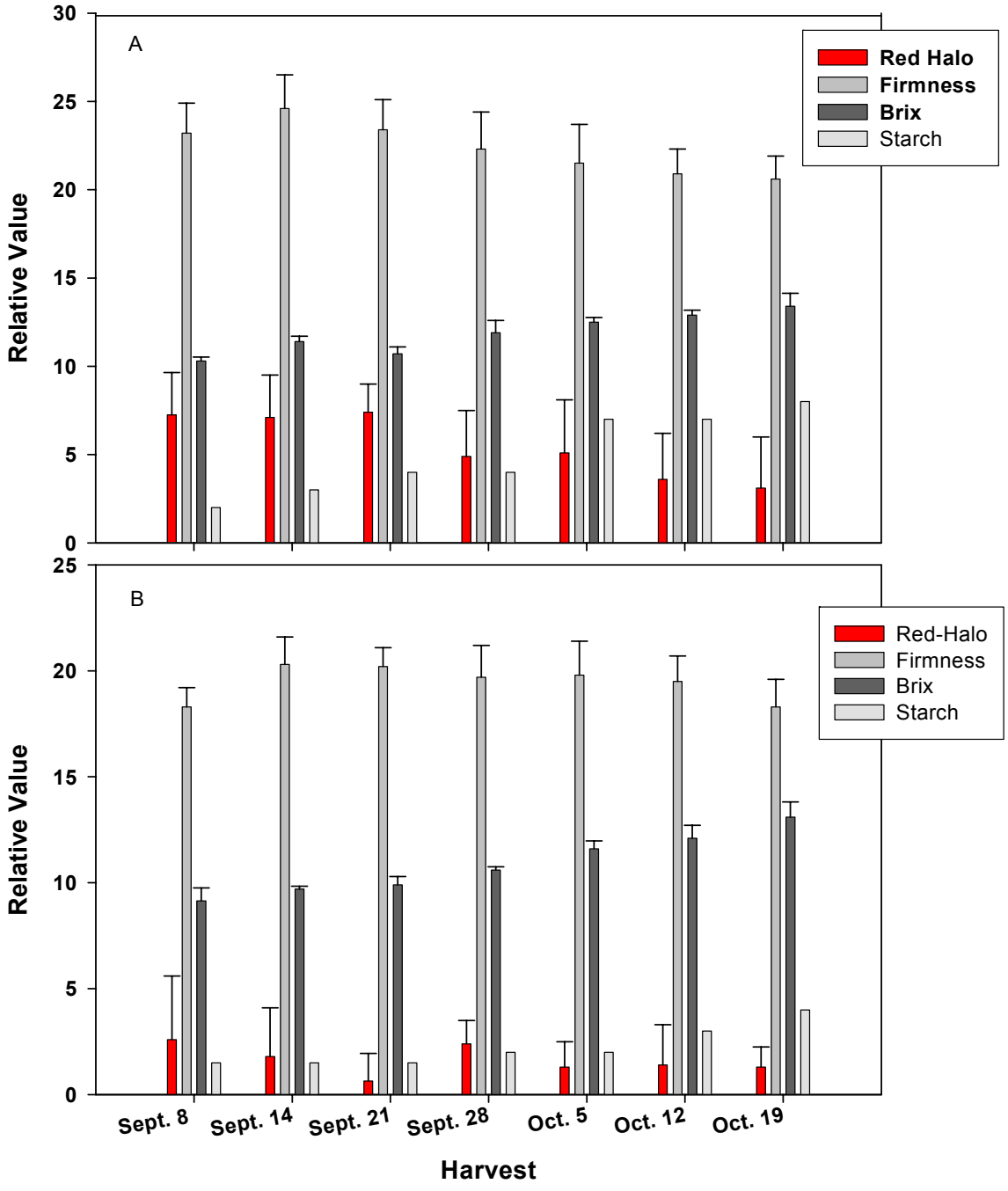


Figure 3. The number of red halos formed compared to firmness, brix, and starch in (A) Rome apples and (B) Red Delicious apples.

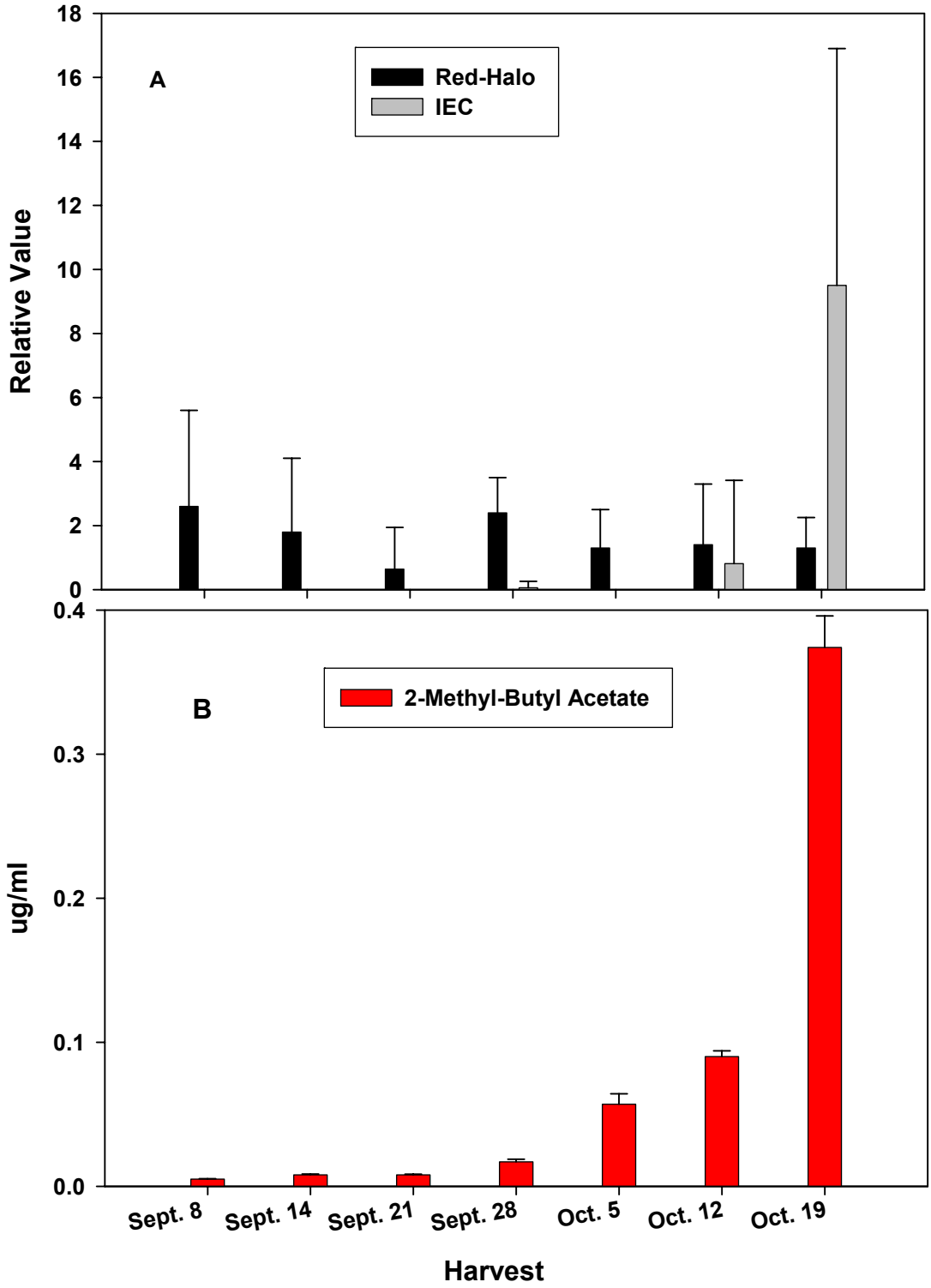


Figure 4. The relationship between red-halo formation, IEC (A), and the major flavor compound, 2-methyl-butyl acetate in Red Delicious apples (B).

Anticipated Results:The development of a simple fruit assay would indicate the exact time of apple climacteric ripening. The red-halo assay would differ in relationship with current apple quality parameters, in that the test would hopefully show a dramatic change at or near the exact time of climacteric. Red halo frequency(black bars) may show highly correlated results with IEC(grey bars) and apple flesh volatile aroma content. If valid, the test then would allow growers a simple field method correlated to tests requiring thousands of dollars in a laboratory setting. The red halo test would have to be routine, accurate, and reliable, as harvest maturity estimations usually determine ultimate profitability. Especially important would be the relationship of fruit storability to the red halo test. Additional scientific benefits to be realized include **fundamental biochemical information** regarding the "triggering" of apple ripening and subsequent regulation thereof.

Budget

Project duration: 2006-2007

Project total (2 years):

Budget justification: Salary is for partial support of Scott Mattinson, Postharvest Physiology Research Associate. Other support for his salary comes from WSU and USDA Special Grant funds. Salary is also requested for an Agricultural Project Associate, a Graduate Student to be named later, who will have principal task management and implementation responsibility. Wages are for part-time student helpers. Principal supply costs include maintenance and operation of orchard, respiration monitoring and CA storage facility, purchase of chemicals, cylinder gases, GC columns, and liquid nitrogen. Miscellaneous costs include publication, graphics and computer support.

Reference:

Rudell, D.R., J.P. Mattheis, X. Fan, and J.K. Fellman. 2002. Methyl Jasmonate Enhances Anthocyanin accumulation and modifies production of phenolics and pigments in 'Fuji' apples. J. Amer. Soc. Hort. Sci. 127(3):435-441. 2002.

Item	Year 1 (2006)	Year 2 (2007)
Salaries		
0.1 FTE DS Mattinson	4,047	4,209
APA	20,698	21,526
Benefits		
40% (Mattinson)	1,619	1,684
1.5%	268	323
Health Insurance	1,559	1,621
Wages	5,500	5,500
Benefits 9%	495	495
Equipment	0	0
Supplies	4,000	3,200
Travel	0	0
Miscellaneous	0	500
Total	38,186	39,058

NEW PROJECT PROPOSAL **PROPOSED DURATION: 1 YEAR**

Project Title: Orchard mechanization/automation
PI: Dana Faubion
Organization: WSU Extension, Yakima
faubiond@wsu.edu
Contract administrator: Rena Koler, Yakima County.

Team description
Dana Faubion, operation leader
Tom Auvil, integrator, bed planting
Karen Lewis, integrator, ergonomics, focus orchard development
Clark Seavert, economist
Nagarajan Ramalingam, engineering
Jenny Loyd, technical coordinator

This is a resubmitted mechanization project proposal originally submitted and approved by the tech committee 12/05. This proposal was not funded by the WTFR Commissioner due to:

WSU decline to fund 40% of the project manager salary
Lack of clarity on the Over the Row (OTR) system development
Lack of clarity on the bed system
Lack of clarity on the overall projects leadership and management.

OTR guidance committee: Jerry Haak, Ruben Canales, Jack Maljaars, Bruce Allen, Mario Martinez, Dave Allan, and Charlie de La Chapelle
Bed planting guidance committee: Dave Allan, Ruben Canales, Jerry Haak, and Charlie de La Chapelle
Harvest Trailer guidance committee: Malcolm Hanks, Brad Newman, Brent Milne, and Walt Hough

Justification: Prior effort of this team has focused on integration and development of platforms. Production risk due to labor issues continues to grow. Our effort needs to continue to guide the progress towards less labor risk. We will add to our effort the facilitation, integration, and evaluation of the Over the Row (OTR) and planting bed system development.

Objectives:
1) Determine ladder vs. mechanization labor productivity change.
   a) Identify workforce management issues associated with mechanization.
   b) Identify and assess ergonomic implications of mechanization efforts.
2) Push forward the development of the OTR mechanical concept.
3) Push forward the bed planting system trial.
4) Develop harvest trailer.
5) Continue to build partnerships and momentum with the sole intent minimizing the human energy expended to produce tree fruit.

Methods:
1) Evaluate ladder vs. mechanization labor productivity change.
   a) Document workforce management issues associated with mechanization.
   b) Identify and assess ergonomic implications of mechanization effort.

Five Focus or COS orchards will provide the backbone of the economic data associated with mechanization in 2006. These orchards will utilize semiautonomous equipment (Jnr. Pete) and will provide work area for collaborators as well as continued demonstration sites. Project leader; Karen

2) Push forward the development of the Over The Row (OTR) mechanical concept.
Utilize the OTR committee to help guide the development of this unit. Ram will function as project engineer for this concept development. The team will support Rams efforts and attempt to minimize production and implementation delays. Contingent budget items 1) Fabrication of the OTR unit; if contingent funding is approved the work will be sole sourced from WTFRC to Vinetech, Prosser. 2) Ram's budget is a draft at this point but contingent funding is requested. During the 2nd quarter meeting a more detailed, OSU approved budget will be submitted.

3) Push forward the bed planting system trial.
Utilize the bed planting guidance committee to design and implement a test planting of the bed system by spring of 2007. Tom will be project leader for the bed planting. Coordination of rootstock accumulation is under way. Site selection and planting design meetings will be held by the bed committee.

4) Develop harvest trailer.
With Malcolm and the committee, design and build a trailer that will flow fruit from the mechanized platform to a sorter/dry bin filler on a trailer. This device will be used to evaluate the field usage of a select dry bin filler. If fruit damage is less than hand harvest, use this device to evaluate the % of culls that can be removed by a sorter prior to the bin filler. Project leader; Dana.

5) Continue to build partnerships and momentum with the intent to minimizing the human energy expended to produce tree fruit.
This will be a continued effort of each team member.

Current Situation:

New technology introduction and monitoring requires sustained focused attention. To date, the team has monitored economic and workforce impact, kept the machinery safely working, built outside collaborations and made design improvements to the hardware. A new project technical coordinator (Jenny Loyd) will be tasked to keep the daily activity focused on accomplishing the objectives as well as utilizing the team members and committees to enhance the orchard and mechanical systems. Productivity will be tracked and evaluated using Seavert's TEAM model.

Schedule of accomplishments:
1) Hire technical coordinator to manage on time, collaborative development.
2) Establish five focus orchards:
   a) Create an environment surrounding the orchards that nurtures collaborative development of new technology to enhance productivity.
   b) Provide yearlong mechanization support and maintain non mechanized control areas
   c) Gather economic, workforce, and ergonomic data – summarize in Seavert's TEAM.
3) Field evaluate the OTR machine at multiple sites.
4) Build a work plan to establish a bed planting with OTR technology in mind. This will be planted spring 2007.
   a) Identify and obtain economic support for establishment of the row crop block (IFTA, Nursery Industry etc.)
5) Design, build and field test the concept of the towable bin filler/sorting trailer that works with Jnr.

Project title:
PI: Auvil, Seavert, Lewis, Faubion, Nagarajan Ramalingam
Project duration: 1 year
Current year: 2006
Project total (1 years): **$148,377**

Item	**Year 1 (2006)**
Salaries[1]	**17,190**
Benefits (29%)	**4,985**
Harvest trailer[2]	**--**
Machine support[3]	**11,000**
Supplies[4]	**1,600**
Travel[5]	**16,000**
Miscellaneous	
Total (WSU- Yakima)	**50,775**
Contingency Funding	
OTR Fabrication (WTFRC)[6]	
Mast, outriggers, gondolas, tractor (4 month rental)	**47,000**
Sprayer, tank, drop booms	**23,500**
Ram Support (OSU)[7]	**27,102**
Total	

[1] 60% technical coordinator salary (Jenny Loyd), remainder provided by other grant funds.

[2] Carryover from 2005 (~15K), will be used to fund harvest trailer development

[3] Fabrication shop, and purchase 1 ton equipment truck (Yakima County motor pool)

[4] Instrumentation, fruit, safety equipment and tools

[5] $4,000 for Lewis, $4,000 for Faubion, $6,000 for project manager, $2,000 for Seavert

[6] Fabrication and tractor rental will be invoiced to WTFRC. Approval of the proposed amount will allow for timely fabrication.

[7] Ram's support needs to be approved through OSU administration a detailed budget will be presented at the 2nd quarter meeting.