CALIFORNIA APPLE COMMISSION

ANNUAL REPORT 2013 – 2014

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2013 – 2014

CALIFORNIA APPLE COMMISSION

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Alexander J. Ott, Executive Director of the California Apple Commission.

STATE APPLE ACREAGE:*

Butte	30 acres
Calaveras	12 acres
Contra Costa	20 acres
El Dorado/Alpine	850 acres
Fresno	448 acres
Humboldt	32 acres
Inyo/Mono	6 acres
Kern	1,110 acres
Kings	65 acres
Lassen	1.5 acres
Los Angeles	35 acres
Madera	120 acres
Marin	7.26 acres
Mariposa	60 acres
Mendocino	254 acres
Merced	2 acres
Modoc	20 acres
Monterey	83.25 acres
Nevada	7.5 acres
Kings	46 acres
Placer	47 acres
Plumas/Sierra	10 acres
Riverside	23 acres
Sacramento	346 acres
San Benito	245 acres
San Bernardino	282 acres
San Diego	286 acres
San Joaquin	3,610 acres
San Luis Obispo	170 acres
San Mateo	14.45 acres
Santa Barbara	38 acres
Santa Clara	120 acres
Santa Cruz	2,128 acres
Shasta	40 acres
Siskiyou	3.86 acres
Solano	146 acres
Sonoma	2,195 acres
Stanislaus	687 acres
Sutter	16.5 acres
Tehama	19.5 acres
Trinity	3 acres
Tulare	35 acres
Tuolumne	154 acres
Ventura	310 acres
Yolo	179.75 acres
Yuba	9 acres
TOTAL	14,271.57 acres

*Total CA Apple Acreage is based on the 2012 County Crop Reports and makes no distinction between fresh, processed and farmers markets. The California Apple Commission only represents growers that produce 40,000 pounds or more of fresh apples.

MESSAGE FROM THE EXECUTIVE DIRECTOR

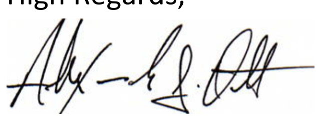
First, I want to thank the industry for their continued support of the California Apple Commission. In June of 2014, the California Department of Food and Agriculture (CDFA) announced the continuation of the Commission for another five years. With substantial support from the industry and no opposition towards the program during testimony, the department ruled to approve the continuation of the Commission once again. Thank you.

Additionally, the industry made great strides in the 2013-2014 year. The California Apple Commission continues to provide research on important issues such as fire blight, and quarantine and pre-shipment requirements. Additionally, the Commission continues to oversee export programs, providing the necessary oversight and cooperation with both foreign and U.S. government agencies.

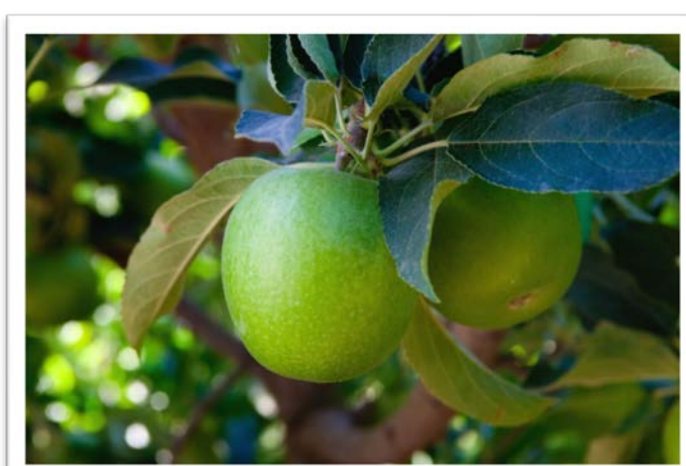
The Commission continues to represent the needs of the industry in important issues that have a direct impact on growing, harvesting, and marketing of California apples.

The California Apple Commission is pleased to present you with its annual report for the 2013 – 2014 year. Again, thank you for your continued support and please do not hesitate to contact us to provide feedback on how we may continue to assist you and the industry.

High Regards,



Alexander J. Ott
Executive Director



THE CHAIRMAN'S CORNER

The California Apple Commission was approved by the California Department of Food and Agriculture to continue its activities for another five years. Although the industry continues to face challenges including: pests and diseases, drought, labor and increase costs just to name a few; the Commission continues to move forward on these important issues all while facing reduced resources. However, our continued working relationships with the California Blueberry industry and the California Olive industry continues to show what industries can do when they work together.

In addition, the Commission continues to "do those things that an individual grower can't", such as overseeing our government export programs, obtaining grants for research and market access issues, educating government and regulatory officials and consumers, and being our liaison between the industry and the government which continues to provide a vital asset to the California apple industry.

It continues to be a pleasure to serve the industry as your Chairman and I continue to look forward in assisting the industry in the months ahead.

Sincerely,

Dr. Steve Blizzard, Chairman

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CALIFORNIA APPLE COMMISSION

BOARD OF DIRECTORS
2013 - 2014

DISTRICT 1

Producer Members

David Rider
Bruce Rider & Sons
Term: 7/ 2012 – 6 /2016

Lance Shebelut
Trinity Fruit Sales
Term: 7/ 2012 – 6 /2016

Tad Kozuki
Kozuki Farming, Inc.
Term: 7/ 2013 – 6 /2017

Handler Member

Bill Denevan
Denevan Apple
Term: 7/ 2013 – 6 /2017

Alternate Member

Tim Huebert
Huebert Farms
Term: 7/ 2013 – 6 /2014

DISTRICT 2

Producer Members

Chris Britton
BK Partners
Term: 7/2010 – 6/2014

Virginia Hemly Chhabra
Greene & Hemly
Term: 7/2010 – 6/2014

VACANT
Term: 7/2012 – 6/2016

Handler Member

Dr. Bruce Hesse
Farmington Fresh
Term: 7/2012 – 6/2016

Alternate Member

VACANT
Term: 7/ 2013 – 6 /2014

DISTRICT 3

Producer Members

Jeff Colombini
Lodi Farming
Term: 7/2013 – 6/2017

Larry Stonebarger
Chinchiolo Stemilt CA
Term 7/2010 – 6/2014

Steve Chinchiolo
Riverbend Orchards
Term: 7/2010 – 6/2014

Handler Member

Tim Sambado
Prima Frutta
Term: 7/2013 – 6/2017

Alternate Member

VACANT
Term: 7/ 2013 – 6 /2014

PUBLIC MEMBER

Dr. Steve Blizzard
Lagomarsino Group
Term: 7/2013 – 6/2017

DISTRICT MAPS

Approved 3-7-2011

STATEMENT FOR ACTIVITIES
FISCAL YEAR ENDED JUNE 30, 2013

ASSETS

• CASH	$180,771
• ACCOUNTS RECEIVABLE	$35,117
• PREPAID EXPENSES	$3,500
• RESTRICTED CASH DUE TO PENDING LAWSUIT	$1,480,098
• PROPERTY AND EQUIPMENT NET OF ACCUMULATED DEPRECIATION OF $33,786 IN 2013 AND $30,089 IN 2012	$6,270
TOTAL ASSETS	**$1,705,756**

LIABILITIES

• ACCOUNTS PAYABLE	$9,870
• ACCRUED COMPENSATED ABSENCES	$9,632
TOTAL CURRENT LIABILITIES	**$19,502**

NET ASSETS

• RESTRICTED	
- ESCROW ACCOUNT	$1,480,098
• UNRESTRICTED	$206,156
NET ASSETS	**$1,686,254**

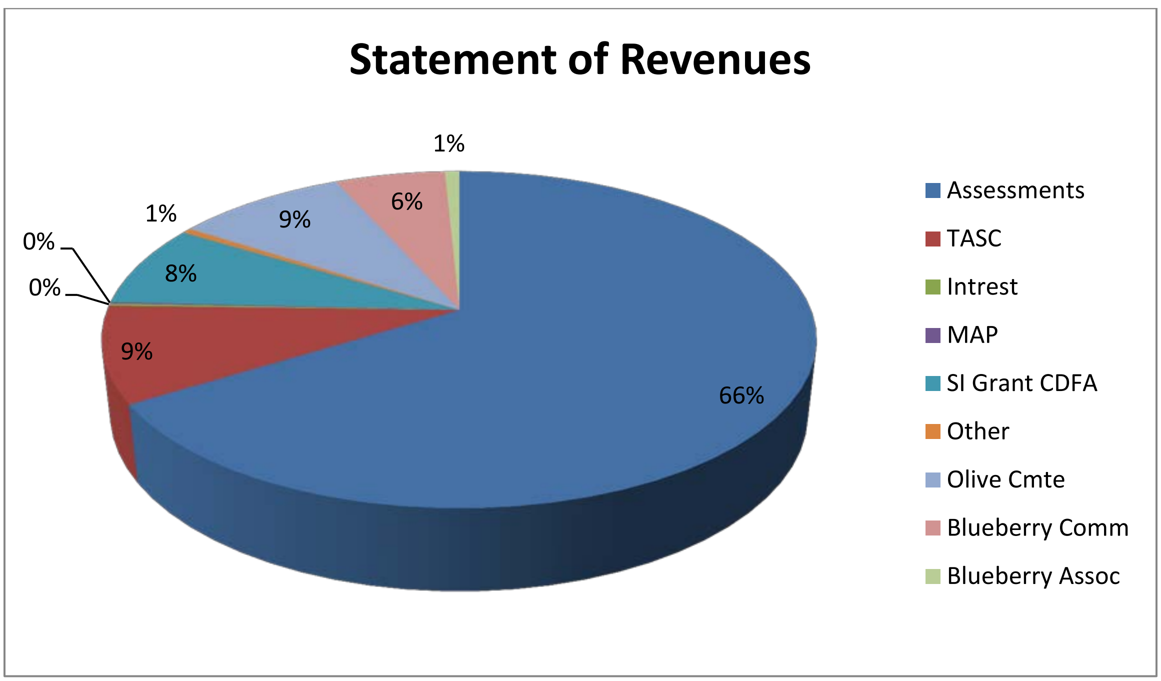
TOTAL LIABILITIES AND NET ASSETS	**$1,705,756**

STATEMENT OF REVENUES

REVENUES

• ASSESSMENTS	$505,478*
• GRANT INCOME – TASC	$70,581
• OLIVE MANAGEMENT FEES	$70,000
• BLUEBERRY MANAGEMENT FEES	$45,000
• BLUEBERRY ASSOCIATION MANAGEMENT FEES	$6,000
• MAP REIMBURSEMENTS	$1,008
• STARCH-IODINE GRANT	$60,222
• INTEREST	$1,750
• OTHER	$3,850

TOTAL REVENUES **$763,889**



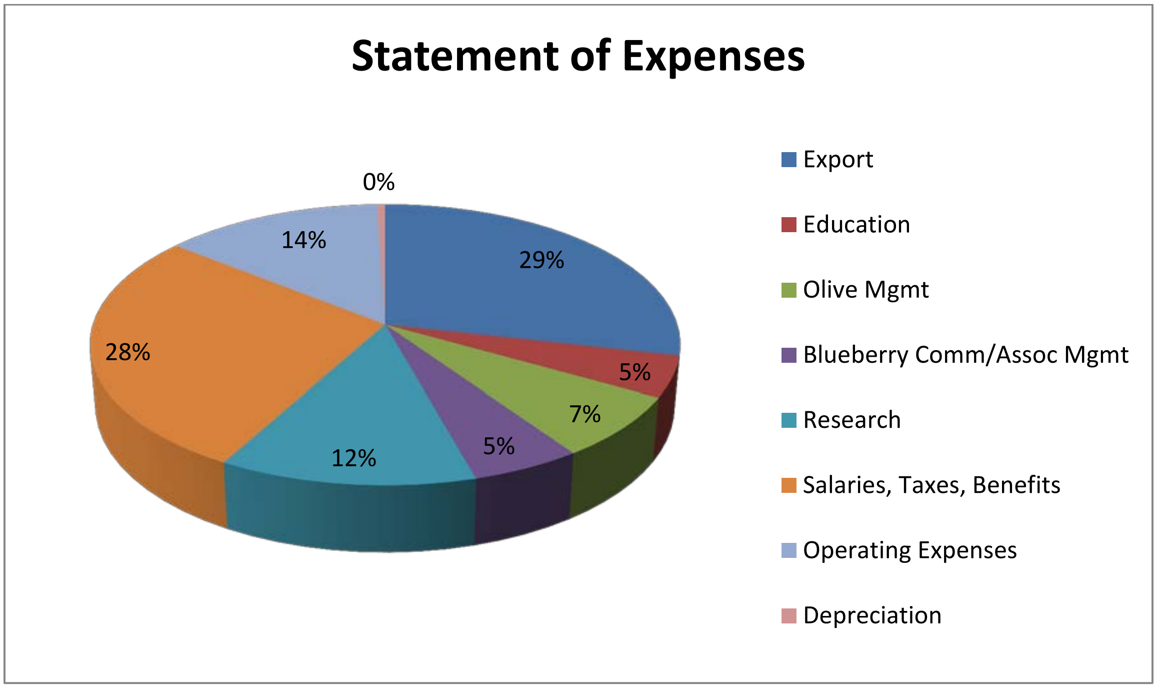
*Includes restricted revenues received pending current lawsuit. Restricted funds shall not be used in operating budget and are stored in a separate escrow account. These funds may not be released until lawsuit is finalized.

STATEMENT OF EXPENSES

EXPENSES

• EXPORT/MARKET DEVELOPMENT	$209,953
• EDUCATION	$34,610
• OLIVE MANAGEMENT	$52,779
• BLUEBERRY MANAGEMENT	$39,025
• RESEARCH	$90,761
• SALARIES, PAYROLL TAXES, BENEFITS	$204,127
• OPERATING EXPENSES	$101,341
• DEPRECIATION	$3,697

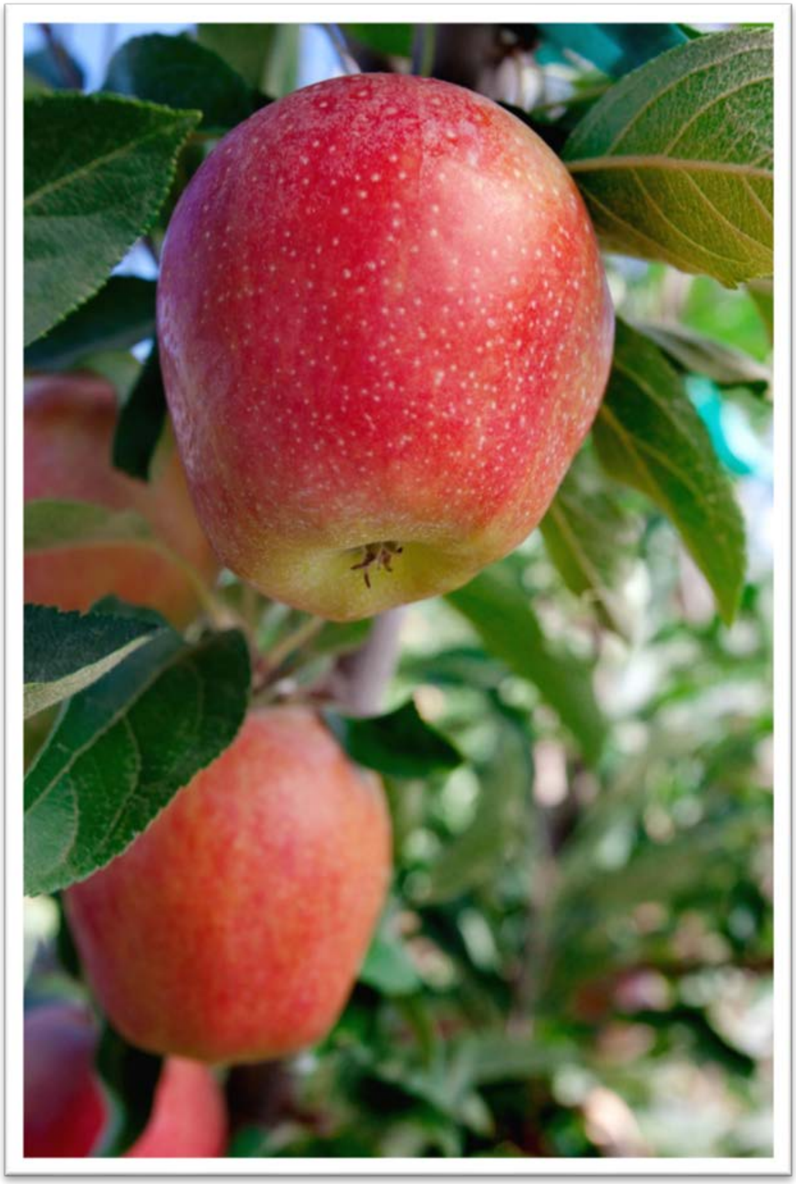
TOTAL EXPENSES **$736,293**



CHANGES IN NET ASSETS **$27,596**

NET ASSETS, BEGINNING OF YEAR **$1,658,658**

NET ASSETS, END OF YEAR **$1,686,254**



CALIFORNIA APPLE RESEARCH PROJECTS

CALIFORNIA APPLE COMMISSION RESEARCH SUMMARY 2013-2014

In 2013-2014, the California Apple Commission focused on several research projects. Some projects are continuations from prior research, while other projects began during the season.

The Research Committee for the California Apple Commission approved three research proposals during the 2013 year. A fourth was conducted under the California Blueberry Commission Research Committee but included apples within the research. All research projects are included within this packet.

These projects included:

1) *Evaluation of new bactericides for control of fire blight of apples caused by Erwinia amylovora and evaluation of new postharvest fungicides for pome fruits* – Dr. Jim Adaskaveg[1]

2) *Systems-based strategies for postharvest insect control: Mortality and removal of light brown apple moth, codling moth, brown marmorated stink bug, and other insect pests in California apples during packing and export* – Dr. Spencer Walse

3) *The postharvest treatment of California apples with cylinderized phosphine to control Oriental fruit moth (OFM)*– Dr. Spencer Walse and Steven Tebbets

4) *The postharvest fumigation of California blueberries to eliminate insects with potential to serve as export trade barriers* – Dr. Spencer Walse and Steven Tebbets[2]

[1] $8,000 was provided by Arysta LifeScience to complete this project
[2] Funding for this research project was provided by the California Blueberry Commission. Though not specifically mentioned in the project title, it also demonstrates the effect of postharvest fumigation of California apples to eliminate insects with the potential to serve as export barriers.

Annual Report - 2013

Prepared for the California Apple commission

Project Title:	Evaluation of new bactericides for control of fire blight of apples caused by *Erwinia amylovora* and evaluation of new postharvest fungicides for pome fruit
Project Leader:	Dr. J. E. Adaskaveg, Department of Plant Pathology, University of California, Riverside CA 92521.
Cooperators:	L. Wade (Arysta Life Science), Dr. H. Förster, D. Cary, and D. Thompson

SUMMARY

Fire blight

1. All strains of *E. amylovora* were found to be sensitive against the antibiotics oxytetracycline and kasugamycin; whereas some strains were streptomycin-resistant and persisted in commercial orchards.
2. In toxicity studies with three biocontrol agents against chemicals used for fire blight control in our field studies, streptomycin, oxytetracycline, kasugamycin, captan, and mancozeb at 40 ppm were all inhibitory against *Streptomyces lydicus* (Actinovate) and *Bacillus amyloliquifaciens* (Double Nickel 55). In contrast, *Aureobasidium pullulans* (Blossom Protect) was not inhibited in growth by the three antibiotics at 40 ppm, but was inhibited by captan and mancozeb. These data indicate that in field applications only Blossom Protect could be safely used in combination with the three antibiotics.
3. In a field trial on the management of fire blight on Granny Smith and Fuji apple, kasugamycin continued to be highly effective. The product performed well by itself, but also in mixtures with copper, Firewall, or Actigard. Registration of Kasumin is expected for 2014.
4. The phosphonates Prophyt, K-phite, and Ko-phite did not show significant activity in a field trial.

Postharvest decay control

1. Postharvest experimental packingline studies focused on new treatments for the management of major decays to provide solutions for conventionally treated and potentially also for organic fruit production. Treatments are being developed based on anti-resistance strategies. The final pre-mixture formulation of fludioxonil and difenoconazole (e.g., Academy), the new multi-pack formulation of fludioxonil and TBZ (e.g., Scholar Max MP), the bio-fungicide polyoxin-D, and a new active ingredient for postharvest decay control (i.e., N-1) were evaluated. The latter two are exempt from tolerance by the US-EPA.
2. Experimental packingline studies again demonstrated that re-circulating high-volume drench applications are the most effective method to provide excellent coverage and decay control.
3. Applications with Academy, Scholar Max MP, Scholar, and Penbotec were all highly effective in reducing blue mold (caused by TBZ-sensitive and -resistant strains of *P. expansum*) and gray mold. Academy and Scholar Max MP also reduced the incidence of bull's eye rot to low levels.
4. Academy, Scholar Max, and Scholar were also highly effective against Alternaria rot and bitter rot (caused by *Colletotrichum acutatum*). This further broadens the spectrum of activity of the fludioxonil-difenoconazole pre-mixture Academy that includes now blue mold, gray mold (TBZ-sensitive and –resistant pathogen populations), bull's eye rot, Alternaria rot, and bitter rot.
5. Polyoxin-D was less effective against gray mold in this year's studies as compared to last year, but highly effective against Alternaria rot. In a timing study, however, polyoxin-D was very effective against gray mold when applied within 10 h of inoculation. It is suggested that fruit cultivar and maturity are critical for the optimum performance of this compound and these parameters need to be further evaluated.
6. N-1 showed moderate efficacy against blue mold and good efficacy against gray mold and Mucor rot. This compound was also more effective when treatments were applied after shorter post-inoculation incubation periods. As with polyoxin-D, further studies are needed to optimizing performance of this compound. This is important because both polyoxin-D and N-1 potentially could be used for organic production and they also could be used in mixtures to prevent resistance of gray mold to fludioxonil.

INTRODUCTION

Epidemiology and management of fire blight. Fire blight, caused by the bacterium *Erwinia amylovora*, is a very destructive disease of pome fruit trees worldwide. It is one of the most difficult diseases to manage. The infection period is long, and moreover, very few effective treatments are available. Integrated programs that combine sanitation and orchard management with chemical and biological controls are the best approaches. If the disease is in its early stage and only a few twigs are blighted, it often can be eliminated by pruning. Thus, aggressive and regular scheduled pruning of diseased tissue is essential for keeping inoculum levels low in an orchard.

Current chemical control programs for fire blight control are based on protective schedules, because available compounds are contact treatments and are not systemic. Control with copper compounds is only satisfactory when disease severity is low to moderate. Copper treatments can be effective, especially under lower disease pressure, but are not commonly being used because they may be phytotoxicity on fruit and cause russeting. New formulations of copper, however, allow for reduced rates based on the metallic copper equivalent (MCE) and thus, extended usage past the bloom period may provide an effective rotational treatment or mix-partner without causing phytotoxicity. Additionally, copper products are approved for organic production and will have to be more extensively used because antibiotic use may become restricted in the future.

The antibiotic streptomycin has been used for many years; whereas the less effective antibiotic oxytetracycline (terramycin) has been used on apples for the last 7 years in California. Because of lack of alternative control materials, resistance developed against streptomycin at many locations in California. We identified a new streptomycin-resistance mechanism in California and this is currently being summarized in a manuscript. In our previous antibiotic resistance surveys over several years, we also detected strains of *E. amylovora* with reduced sensitivity to oxytetracycline at several locations. At one of these locations field treatments with oxytetracycline (e.g., Mycoshield, Fireline) were reported to be ineffective in controlling the disease. Thus, field resistance has occurred in some locations.

In the past years, in our evaluations of new materials for fire blight control, kasugamycin (Kasumin) was identified as the most effective alternative treatment with an efficacy equal or higher to streptomycin or oxytetracycline. This compound also showed very good efficacy in controlling fire blight in field trials in other pome fruit growing areas of the country. Although concerns have been expressed by regulatory agencies regarding the use of antibiotics in agriculture, kasugamycin is not used in human and animal medicine and has a different mode of action from streptomycin or oxytetracycline (no cross-resistance). Through our efforts, registration of Kasumin in California is pending in 2014. Kasugamycin was again effectively used in our field trials in 2013. It was applied by itself or in mixtures with selected other materials, including other antibiotics, copper, mancozeb, and Actigard that is enhancing host defense mechanisms in some plants. These evaluations were done to identify effective mixture treatments that would reduce the potential for resistance development. In the past, we also successfully evaluated rotation programs with Kasumin. In 2013, we also tested the phosphonates Prophyt, K-Phite, and Ko-phite, the biocontrols Blossom Protect and Actinovate, and several mixture treatments.

Management of postharvest decays. Apples, like other pome fruit, can be stored for some period of time using the correct storage environments. Still, postharvest decays caused by fungal organisms can cause serious crop losses. The major postharvest decays of apples include *Penicillium expansum, Botrytis cinerea, Alternaria alternata*, and *Mucor piriformis* causing blue mold, gray mold, black mold, and Mucor decay, respectively. Bull's eye rot caused by *Neofabraea* species can be a major problem in apple growing areas of the Pacific Northwest, but can also cause losses in California. Bitter rot caused by *Colletotrichum acutatum* mostly occurs in wet climates.

New postharvest fungicides including Penbotec (pyrimethanil - 2005), Scholar (fludioxonil - 2005), and Judge (fenhexamid – 2007) were developed by us and others because Captan at the registered postharvest rate of 2 lb/200,000 lb is ineffective against blue mold and TBZ-resistance (Mertect 340F or Alumni) is widespread in populations of *B. cinerea* and *P. expansum.* These new treatments are just recently being utilized in California and the Pacific Northwest (PNW) because many countries had to establish maximum residue limits (MRLs) to allow the import of fruit.

Although five fungicides (Captan, TBZ, Scholar, Penbotec, Judge) are now registered for postharvest use on apple, only two of them (Scholar, Penbotec), are highly effective against TBZ-resistant blue mold. Resistance to Penbotec in the field and in the packinghouse, however, has already been reported in other pome fruit growing areas of the US (e.g., PNW). Anti-resistance strategies include the use of fungicide rotations and mixtures. For this, we are identifying additional potential postharvest fungicides, and we continued our evaluation of the sterol biosynthesis inhibitor difenoconazole. We have been working in close collaboration with the registrant of Scholar and difenoconazole. One goal is to ultimately provide a pre-mixture of these fungicides that is both highly efficacious and cost-effective. For this, we have been optimizing usage rates, application methods, and we have been evaluating different fludioxonil-difenoconazole pre-mixture formulations for managing gray mold, blue mold, Alternaria rot, and bull's eye rot. Although this latter decay is only of sporadic importance in California (but very important in the Pacific Northwest), management strategies need to be known in the event of a disease outbreak.

As an additional alternative, we are evaluating the bio-fungicide polyoxin-D that has obtained an exempt registration status in the United States as a potential postharvest treatment for organic production. We obtained excellent gray mold reduction in previous studies using this compound, and in 2013 we continued its evaluation. Furthermore, another compound (N-1) was evaluated as a postharvest treatment on pome fruit and other crops. N-1 is known for its activity against *Penicillium* species and it has been used as a food additive for many years. The compound has the potential to obtain an exempt status and an organic registration because it is a natural fermentation product. Furthermore, over all the years in use, resistance in *Penicillium* species against N-1 has not occurred. N-1 was never evaluated on pome fruit and thus, we conducted studies on its use as a postharvest treatment.

These latter two alternative treatments could also be used as components of anti-resistance management for currently registered fungicides. Thus, for fludioxonil (Scholar), difenoconazole has been developed to prevent resistance in *Penicillium* populations. Polyoxin-D or N-1 could take this role for *B. cinerea*, because difenoconazole has little activity against gray mold. Thus, in 2013, our apple postharvest research focused on new treatments for the management of major decays to provide solutions for conventionally treated and potentially also for organic fruit production. Treatments are being developed for long-term usage because they are integrated with anti-resistance strategies.

OBJECTIVES FOR 2013

Fire blight research

1. Evaluate the efficacy of treatments for managing fire blight and characterize antibiotic resistance.
   - A. Laboratory in vitro tests to evaluate the bactericidal activity of antibiotics with and without biofilm inhibitors such as 2-aminoimidazole using spiral gradient dilution assays.
   - B. Small-scale hand-sprayer tests using different treatment-inoculation schedules to evaluate bio-film inhibitors in combination with antibiotics and/or low MCE copper products.
   - C. Field trials with protective air-blast spray treatments:
     - i. New formulations of copper (e.g., Kocide 3000, Badge X2) with and without antibiotics.
     - ii. Plant defense activators (e.g, ProAlexin, Actigard, PM-1) with and without antibiotics.
     - iii. Evaluate the efficacy of biological controls (e.g., Actinovate, Blossom Protect, Double Nickel 55), and natural products (e.g., Cerebrocide) in integrated programs using antibiotics and low MCE copper products.
   - D. Characterization of streptomycin- and oxytetracycline-resistant strains using molecular approaches: characterize plasmids that harbor the resistance genes and compare to *E. amylovora* populations from other parts of the country.

Postharvest research

2. Comparative evaluation of new postharvest fungicides
   - A. Evaluate difenoconazole, fludioxonil, and difenoconazole-fludioxonil pre-mixtures at selected rates against gray mold, blue mold, Alternaria decay, and bull's eye rot and compare to pyrimethanil.
   - B. Evaluate polyoxin-D and Nm-1 against gray mold, Alternaria decay, and bull's eye rot and compare to pyrimethanil and fludioxonil.
   - C. Evaluate treatment effects on fungicide residues on apple fruit – determine the effect of temperature differences between treatment solution and fruit on uptake of fludioxonil and difenoconazole of different apple cultivars.
   - D. Determination of baseline sensitivities. Baseline sensitivities for fludioxonil and difenoconazole will be continued to be developed for additional isolates of *Alternaria* spp. that are collected.

MATERIALS AND METHODS

Isolation of* E. amylovora*, bacterial culturing, and verification of species identity. Diseased apple blossoms with fire blight symptoms were obtained in the spring and early summer of 2013. Surface-disinfested, infected plant material (fruit, stems, and pedicels) was incubated in sterile water for 15 to 30 min to allow bacteria to ooze out. Suspensions were streaked onto YDC plates. Single colonies were transferred and the identity of strains as *E. amylovora* was verified by colony morphology and by PCR (using primers for the *E. amylovora* plasmid pEA29). Detection of a DNA fragment using gel electrophoresis confirmed a positive identification.

***Laboratory studies on the toxicity of bactericides against* E. amylovora.** Kasugamycin (Kasumin 2L, Arysta Life Sciences, Cary NC), streptomycin (Sigma, St. Louis, MO), oxytetracycline (Sigma), and the biofilm inhibitor 2-aminoimidazole (along with an analog) were evaluated for their in vitro toxicity using the spiral gradient dilution method. For this, a radial bactericidal concentration gradient was established in nutrient agar media in Petri dishes by spirally plating out a stock concentration of each antimicrobial using a spiral plater (Autoplate 4000; Spiral Biotech, Inc., Norwood MA). After radially streaking out suspensions of the test bacteria (10 µl of 10^8 cfu/ml-based on optical density at 600 nm and use of a standard curve) along the concentration gradient, plates were incubated for 2 days at 25ºC. Measurements were visually taken for two inhibitory concentrations: i) the lowest inhibitory concentration (LIC; the lowest concentration where inhibition of bacterial growth was observed, i.e., where the bacterial streak became less dense visually), and ii) the minimal concentration that inhibited growth by >95% (MIC). The actual antibiotic concentrations were obtained by entering the radial distances of inhibition (measured from the center of the plate) into the Spiral Gradient Endpoint program (Spiral Biotech, Inc.).

Toxicity of chemicals used for fire blight control in our studies against three biocontrol agents. The spiral gradient dilution method was used to evaluate the toxicity of streptomycin, oxytetracycline, kasugamycin, captan, and mancozeb against *Streptomyces lydicus* (Actinovate), *Aureobasidium pullulans* (Blossom Protect), and *Bacillus amyloliquifaciens* (Double Nickel 55). Stock concentrations of the chemical were used that resulted in maximum concentrations in the agar medium of approximately 40 ppm. The biocontrol agents were radially streaked along the concentration gradients, and plates were evaluated after two days. When growth of the biocontrol was inhibited, it was considered sensitive to the chemical.

***Field studies on fire blight using protective treatments during the growing season*.** In a field study in an experimental orchard at KARE, treatments were applied at 25% bloom (3-18) and 85% bloom (3-25-13) to cv. Granny Smith and at 20% bloom (3-25) and 95% bloom (4-3-13) to cv. Fuji using an air blast sprayer at 100 gal/A. Trees were inoculated with *E. amylovora* using an air-blast sprayer on 4-1-13. Disease was evaluated on 4-22-2013, the number of diseased spurs per tree was counted, and potential phytotoxic effects of the treatments were recorded. Data were analyzed using analysis of variance and LSD mean separation procedures of SAS 9.1.

Efficacy of postharvest treatments and application methods using single fungicides and mixtures. The efficacy of Academy (the final formulation of a difenoconazole-fludioxonil pre-mixture), Scholar Max MP (a new multi-pack formulation of fludioxonil and TBZ) was evaluated in comparison with Scholar 230SC and Penbotec. Applications were done using high-volume in-line drench and low-volume CDA spray applications on an experimental packingline using the suggested commercial rates. Granny Smith apples were wound-inoculated with TBZ-resistant isolates of *P. expansum* ($5x10^5$ conidia/ml), or with *B. cinerea* (10^5 conidia/ml), *Neofabraea perennans* or *M. malicortices* (10^6 conidia/ml), *Alternaria alternata* (10^5 conidia/ml), or *Colletotrichum acutatum* (10^5 conidia/ml) incubated for 15-17 h at 20°C, and then treated. Fungicides were applied on an experimental packing line at KARE as aqueous solutions using in-line drench applications that were followed by low-volume spray applications with fruit coating (Decco 231, a carnauba-based coating) or by low-volume CDA spray application at a rate of 25 gal/200,000 lb fruit. For N-1, two formulations (a 50% powder and a 5% liquid formulation) were used and applications were done using either method or a combination of the two.

A timing study was conducted with polyoxin-D and N-1 on apple fruit. Fruit were inoculated and incubated for selected times (4, 6, 9, or 12 h) at 20C. Treatments with aqueous fungicide solutions were done using a hand-sprayer. After treatment, fruit of all studies were stored at 20°C, 95% RH for 6 to 14 days and then evaluated for the incidence of decay. Data were analyzed using analysis of variance and least significant difference mean separation procedures of SAS 9.1.

RESULTS AND DISCUSSION

Antibiotic sensitivity among* E. amylovora *strains collected in California. Strains of *E. amylovora* were confirmed for species identity by PCR amplification of a 1-kb DNA fragment using specific primers for plasmid pEa29 that is ubiquitously found in this bacterium. All strains were found to be sensitive against the antibiotics oxytetracycline and kasugamycin; whereas some strains were streptomycin-resistant. Thus, streptomycin-resistant strains are persistent in commercial orchards. The biofilm inhibitor 2-aminoimidazole along with an analog reported to be similar were shown to be not toxic to the pathogen.

Toxicity of chemicals used for fire blight control in our studies against three biocontrol agents. Results from our in vitro assays indicated that streptomycin, oxytetracycline, kasugamycin, captan, and mancozeb at 40 ppm were all active against *Streptomyces lydicus* (Actinovate) and *Bacillus amyloliquifaciens* (Double Nickel 55) (Table 1). In contrast, *Aureobasidium pullulans* (Blossom Protect) was not inhibited in growth by the three antibiotics at 40 ppm, but was inhibited by captan and mancozeb. These data indicate that in field applications only Blossom Protect could be safely used in combination with the three antibiotics.

Table 1. Activity of chemicals used for fire blight control against three biocontrol agents

Biocontrol product and agent	Streptomycin	Oxytetracycline	Kasugamycin	Captan	Mancozeb
Actinovate (*Streptomyces lydicus*)	+*	+	+	+	+
Blossom Protect (*Aureobasidium pullulans*)	-	-	-	+	+
Double Nickel 55 (*Bacillus amyloliquifaciens)*	+	+	+	+	+

* - Activity was determined using the spiral gradient dilution assay. + = chemical is active against the biocontrol agent, - = chemical is not effective at maximum concentration of 40 ppm tested.

Field studies on fire blight using protective treatments during the growing season.

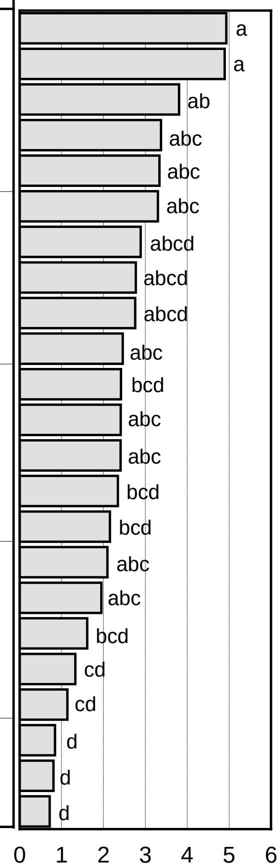
In a field trial on Granny Smith and Fuji apple, 23 and 11 treatments were evaluated, respectively. Kasumin continued to perform very well and was numerically the best treatment on cv. Fuji (Fig. 1). The product was also very effective in mixtures with copper, Firewall, or Actigard. Still, there was no additional disease reduction when Kasumin was used with copper or Actigard as compared to using Kasumin by itself. Mixtures of Kasumin with Firewall or copper can be considered anti-resistance strategies because each mixture component is active against the pathogen. Actigard is a systemic acquired resistance compound (SAR) and stimulates host defense systems in some plants. It has no direct effect on the pathogen and is generally not very active against fire blight when used by itself. Thus, there is no benefit of using this material in mixture treatments with Kasumin (Fig. 1A,B). Actigard also did not improve the performance of Firewall (Fig. 1A).

The biocontrol Blossom Protect was also among the best treatments (Fig. 1A,B). The biocontrol Actinovate was effective when used by itself at the 6-oz rate (Fig. 1A), but not in mixtures with Kasumin (Fig. 1A,B) or copper (Fig. 1A), reflecting the in vitro inhibition of *Streptomyces lydicus* by kasugamycin (see above; copper was not tested in this assay). Copper oxychloride/copper hydroxide (Badge) used by itself also significantly reduced the amount of disease from the control, but the phosphonates Prophyt, K-Phite, and Ko-phite did not show significant activity (Fig. 1AB). The biofilm inhibitor 2-aminoimidazole was not evaluated in the field due to high costs, low amount of material available, and non-inhibitory results in laboratory assays (see above).

Fig. 1. Efficacy of bactericides for fire blight management on Granny Smith and Fuji apple in a field trial at Kearney Ag Center 2013

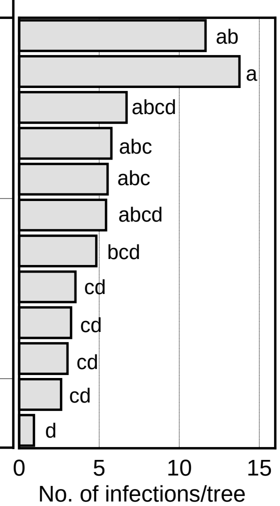
A. Cv. Granny Smith

No.	Treatment	Rate/A
1	Control	
2	Prophyt	3 qts = 96 fl oz
3	K-Phite	3 qts = 96 fl oz
4	Actinovate + Kocide 3000	12 oz + 1.25 lb
5	Kasumin 2L + Badge X2	100 ppm + 8 oz
6	Ko-Phite	3 qts = 96 fl oz
7	Blossom Protect + Buffer + ProAlexin	1.25 lbs + 9.35 lbs + 133 ml
8	Kasumin 2L + Actinovate	100 ppm + 12 oz
9	Kasumin 2L + Actinovate	100 ppm + 24 oz
10	Actinovate + NuFilm P	12 oz + 8 oz
11	Badge X2	8 oz
12	Kasumin 2L + Prophyt	100 ppm + 96 fl oz
13	Fireline	200 ppm
14	Kasumin 2L + Fireline	100 ppm + 200 ppm
15	Blossom Protect + Buffer	1.25 lbs + 9.35 lbs
16	Firewall + Actigard	100 ppm + 2 oz
17	Kasumin 2L + Manzate ProStik	100 ppm + 2 lb
18	Kasumin 2L	100 ppm
19	Actinovate + NuFilm P	6 oz + 8 oz
20	Fireline + Firewall	200 ppm + 100 ppm
21	Firewall	100 ppm
22	Kasumin 2L + Firewall	100 ppm + 100 ppm
23	Kasumin 2L + Actigard	100 ppm + 2 oz



B. Cv. Fuji

No.	Treatment	Rate/A
1	Control	---
2	Kasumin 2L + Actinovate	100 ppm + 24 oz
3	Kasumin 2L + Fireline	100 ppm + 200 ppm
4	K-Phite	3 qts = 96 fl oz
5	Kasumin 2L + Actinovate	100 ppm + 12 oz
6	Fireline	200 ppm
7	Kasumin 2L + Actigard	100 ppm + 2 oz
8	Kasumin 2L + Badge X2	100 ppm + 8 oz
9	Actinovate + Kocide 3000	12 oz + 1.25 lb
10	Badge X2	8 oz
11	Blossom Protect + Buffer	1.25 lbs + 9.35 lbs
12	Kasumin 2L	100 ppm



Treatments were applied at 25% bloom (3-18) and 85% bloom (3-25-13) to cv. Granny Smith and at 20% bloom (3-25) and 95% bloom (4-3-13) to cv. Fuji using an air blast sprayer at 100 gal/A. Trees were inoculated with *E. amylovora* using an air-blast sprayer on 4-1-13. Disease was evaluated on 4-22-2013, and the number of diseased spurs per tree was counted.

In summary, our project on the identification of integrated fire blight programs with copper, fungicides, antibiotics, and biocontrols has identified new treatments that can be adopted by the California pome fruit industries. Registration of Kasumin for use in California is pending in 2014.

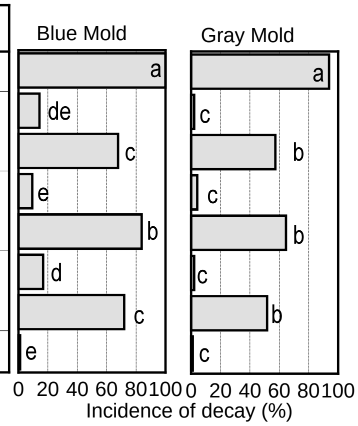
Evaluation of postharvest treatments using single-fungicides, mixtures, and pre-mixtures. Experimental packing line studies using Granny Smith apples were conducted to evaluate new pre-mixture treatments in comparison with single-fungicides, as well as polyoxin-D and a new active ingredient for postharvest decay management, i.e., N-1. Decays studied included blue mold, gray mold, bull's eye rot, and Alternaria rot. The latter decay can be quite serious on injured pome fruit, but was never before included in out postharvest studies. We also evaluated the efficacy against bitter rot. This disease occurs in California but is a major problem in wetter climates.

For the evaluation of the final pre-mixture formulation of fludioxonil-difenoconazole (i.e., Academy) and of a new fludioxonil-TBZ multi-pack formulation (i.e., Scholar Max MP) in comparison with fludioxonil (Scholar) alone, the efficacy was compared using re-circulating, in-line drench versus low-volume, CDA spray applications (Figs. 2-3). In all cases, the efficacy of each treatment was increased when applied as a drench application. During the application on a roller bed, the apple fruit did not rotate well on the roller bars, and thus, fungicide coverage of the inoculation site was poor using a low-volume spray application. Under commercial conditions, certain devices are used to improve fruit rotation during fungicide application, and thus, efficacy of low-volume applications is likely higher. Still, re-circulating high-volume drench applications are the most effective method to provide excellent coverage and decay control.

In-line drench applications with Academy, Scholar Max MP, Scholar, and Penbotec were all highly effective in reducing blue mold (caused by TBZ-resistant strains of *P. expansum*) and gray mold (Fig. 2). Decay incidence was reduced from almost 100% in the control to less than 20%. Penbotec was also highly effective. As indicated previously, Scholar is not effective against bull's eye rot. However, the fludioxonil-difenoconazole mixture Academy and the fludioxonil-TBZ mixture Scholar Max reduced the incidence of decay to low levels on fruit inoculated with *N. perennans* or *N. malicorticis,* similar to Penbotec (Fig. 3). Resistance against pyrimethanil has developed in some populations of the three decay fungi at some locations and thus, Penbotec has to be rotated with different modes of action. Although difenoconazole is not effective against gray mold, and generally did not provide an additive effect in blue mold control when used in mixtures with Scholar as compared to using Scholar alone, registration of the pre-mixture will be an important tool to decrease the risk of fungicide resistance to develop in populations of *Penicillium* spp.

Fig. 2. Evaluation of postharvest applications with new fungicide pre-mixtures for management of blue and gray mold decay of Granny Smith apples in experimental packingline studies

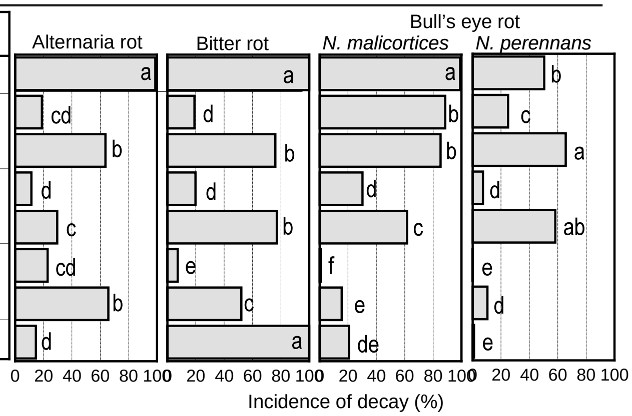
Treatment	A. i.	Method and rate
Control (water)	----	---
Scholar 230SC	fludioxonil	Drench 10 fl oz
Scholar 230SC	fludioxonil	CDA 16 fl oz
Academy 384SC	flud. + difenoc.	Drench 16 fl oz
Academy 384SC	flud. + difenoc.	CDA 16 fl oz
Scholar Max MP	flud. + TBZ	Drench 10 + 16 fl oz
Scholar Max MP	flud. + TBZ	CDA 16 + 16 fl oz
Penbotec	pyrimethanil	Drench 500 ppm



Fruit were inoculated with conidia of a TBZ-resistant isolate of *Penicillium expansum* (5 x 10^5 conidia/ml) or with a TBZ-sensitive isolate of *B. cinerea* (10^5 conidia/ml) and were incubated for 15-17 h at 20C. Treatments with aqueous fungicide solutions were done by in-line re-circulating drench applications that were followed by a CDA application with carnauba fruit coating (Decco 231). CDA applications were done using 25 gal/200,000 lb fruit and treatments were done in carnauba fruit coating. Rates for CDA applications are for 200,000 lb fruit. For Scholar Max MP rates are given separately for the two components, whereas for the pre-mixture Academy the rate is given as a total of the two components. 10 fl oz Scholar = 180 ppm, 16 fl oz = 480 ppm, 16 fl oz Academy = 480 ppm = 10 fl oz Scholar + 10.7 fl oz A8574D. Fruit were then incubated at 20 C for 6 days.

Fig. 3. Evaluation of postharvest applications with new fungicide pre-mixtures for management of Alternaria decay, bitter rot, and bull's eye rot of Granny Smith apples in experimental packingline studies

Treatment	A. i.	Method and rate
Control (water)	----	---
Scholar 230SC	fludioxonil	Drench 10 fl oz
Scholar 230SC	fludioxonil	CDA 16 fl oz
Academy 384SC	flud. + difenoc.	Drench 16 fl oz
Academy 384SC	flud. + difenoc.	CDA 16 fl oz
Scholar Max MP	flud. + TBZ	Drench 10 + 16 fl oz
Scholar Max MP	flud. + TBZ	CDA 16 + 16 fl oz
Penbotec	pyrimethanil	Drench 500 ppm



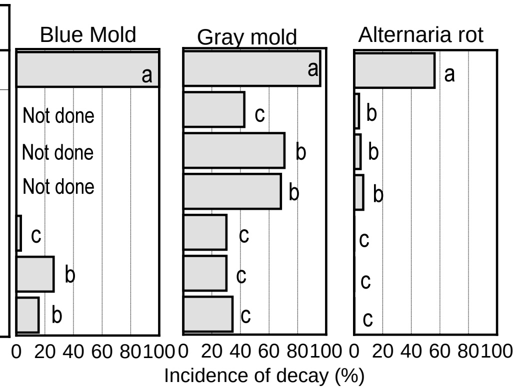
Fruit were inoculated with conidia of *Alternaria alternata, Colletotrichum acutatum, Neofabraea malicortices* (all at 10^5 conidia/ml), or *N. perennans* (10^6 conidia/ml) and were incubated for 15-17 h at 20C. Treatments with aqueous fungicide solutions were done by in-line re-circulating drench applications that were followed by a CDA application with carnauba fruit coating (Decco 231). CDA applications were done using 25 gal/200,000 lb fruit and treatments were done in carnauba fruit coating. Rates for CDA applications are for 200,000 lb fruit. For Scholar Max MP rates are given separately for the two components, whereas for the pre-mixture Academy the rate is given as a total of the two components. 10 fl oz Scholar = 180 ppm, 16 fl oz = 480 ppm, 16 fl oz Academy = 480 ppm = 10 fl oz Scholar + 10.7 fl oz A8574D. Fruit were then incubated at 20 C for 6 days.

For control of Alternaria rot where non-fungicide-treated fruit developed 100% decay, Scholar, Academy, Scholar Max, and Penbotec were similarly effective (Fig. 3). Difenoconazole and fludioxonil were tested last year for their in vitro activity against *Alternaria* sp. and the low EC_{50} values obtained (0.01 to 0.04 ppm for difenoconazole, 0.011 to 0.025 ppm for fludioxonil) support their high effectiveness against this decay. Bitter rot was also reduced to low levels using Scholar, Academy, or Scholar Max (Fig. 3). This further broadens the spectrum of activity of the fludioxonil-difenoconazole pre-mixture with blue mold, gray mold, bull's eye rot, Alternaria rot, and bitter rot. Studies on Alternaria rot will need to be repeated next year. Gray mold, blue mold, bull's eye rot, and Alternaria rot (but not Mucor decay or bitter rot) are also controlled by Penbotec. Resistance against pyrimethanil, however, has developed in populations of *Penicillium, Botrytis,* and *Neofabraea* spp. at some locations and thus, this fungicide has to be rotated with different modes of action.

Fig. 4. Evaluation of polyoxin-D (CX-10440) as a potential new postharvest treatment for management of blue mold, gray mold, and Alternaria rot of Granny Smith apples in experimental packingline studies

In-line drench applications

Polyoxin D	Scholar SC	Difenoconazole
Control (water)	---	---
13.5 fl oz	---	---
6.75 fl oz	---	---
3.4 fl oz	---	---
3.4 fl oz	10 fl oz	---
6.75 fl oz	10 fl oz	---
3.4 fl oz	10 fl oz	10.7 fl oz

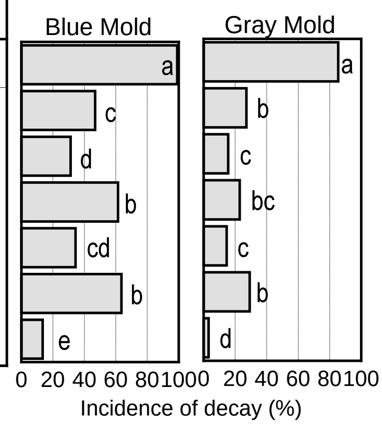


Fruit were inoculated with conidia of a TBZ-resistant isolate of *Penicillium expansum* (5 x 10^5 conidia/ml), *B. cinerea* (10^5 conidia/ml) or *Alternaria alternata* (100,000 conidia/ml) and were incubated for 15-17 h at 20C. Treatments with aqueous fungicide solutions were done by in-line re-circulating drench applications that were followed by a CDA application with carnauba fruit coating (Decco 230). For difenoconazole, the A8574D formulation was used. 10 fl oz Scholar = 180 ppm, 10.7 fl oz A8574D = 300 ppm. Fruit were then incubated at 20 C for 6 days.

In a postharvest packing line study with CX-10440 (polyoxin-D), this treatment was moderately effective against gray mold when used by itself at the 13.5-oz rate or in combination with Scholar (Fig. 4). In last year's studies, it was shown to be highly effective. This indicates that fruit maturity may be critical for the effectiveness of this treatment (see below). Polyoxin was highly effective against Alternaria rot (Fig. 4).

Fig. 5. Evaluation of two formulations of N-1 as a potential new postharvest treatment for management of blue and gray mold decay of Granny Smith apples in experimental packingline studies

Drench application	CDA application
Control (water)	Wax only
N-1 50% form. 1000 ppm	Wax only
N-1 5% form. 1000 ppm	Wax only
N-1 5% form. 500 ppm	N-1 5% form. 500 ppm in wax
N-1 50% form. 500 ppm	N-1 5% form. 500 ppm in wax
---	N-1 5% form. 1000 ppm in wax
N-1 50% form. 500 ppm + 8 fl oz Scholar SC	Wax only



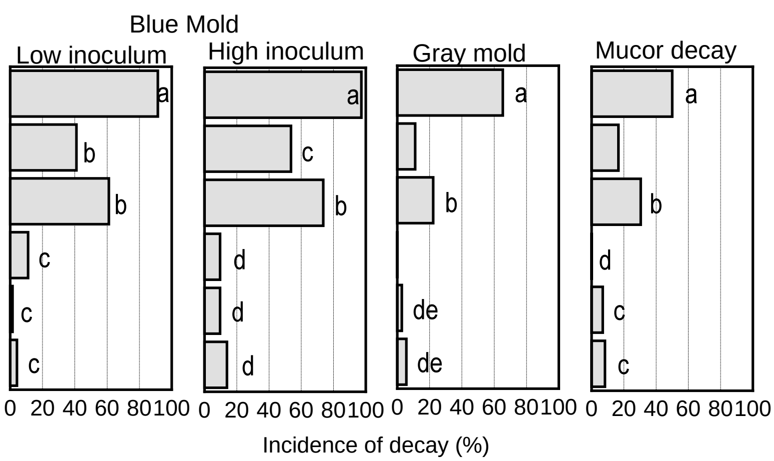
Fruit were inoculated with conidia of a TBZ-resistant isolate of *Penicillium expansum* (5 x 10^5 conidia/ml) or with *B. cinerea* (10^5 conidia/ml) and were incubated for 15-17 h at 20C. Treatments with aqueous fungicide solutions were done by in-line re-circulating drench applications that were followed by a CDA application with carnauba fruit coating (Decco 231). Fruit were then incubated at 20 C for 6 days.

N-1 is a new active ingredient for postharvest use that we evaluated for the first time in 2013. In-line drench treatments or drench-CDA combination treatments were very effective against gray mold and moderately effective against blue mold and Mucor decay (Figs. 5,6). In mixtures with low concentrations of Scholar (8 fl oz = approx. 150 ppm) decay was reduced to very low levels. As with polyoxin-D, the efficacy of this compound may be highly dependent on fruit maturity and the best application strategies still need to be defined.

Fig. 6. Evaluation of two formulations of N-1 as a potential new postharvest treatment for management of blue mold, gray mold, and Mucor decay of Granny Smith apples in experimental packingline studies

In-line drench applications

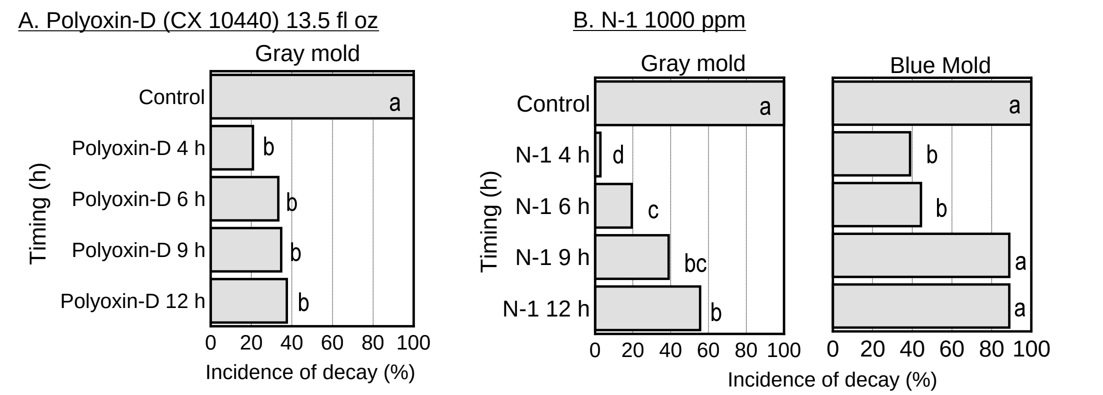
N-1	Scholar SC
Control (water)	---
50% form. 1000 ppm	---
50% form. 500 ppm	---
50% form. 500 ppm	8 fl oz
5% form. 2000 ppm	8 fl oz
---	8 fl oz



Fruit were inoculated with conidia of a TBZ-resistant isolate of *Penicillium expansum* (10^6 or 10^5 conidia/ml), *B. cinerea* (5 x 10^4 conidia/ml) or *M. piriformis* (10^5 spores/ml) and were incubated for 15-17 h at 20C. Treatments with aqueous fungicide solutions were done by in-line re-circulating drench applications that were followed by a CDA application with carnauba fruit coating (Decco 231). Fruit were then incubated at 20 C for 6 days.

In a timing study where treatments with polyoxin-D or N-1 were applied to apple fruit selected times after inoculation, efficacy was shown to be highly dependent on the timing. Thus, for N-1, treatments applied 4 or 6 h after inoculation were significantly more effective than when applied after 9 or 12 h (Fig. 7). A trend for better efficacy in the 4-h timing was also observed for polyoxin-D. Considering that highly susceptible, senescent fruit were used in this latter study, higher efficacy is expected when treating fruit immediately after harvest. Thus, both compounds will have to be continued to be evaluated. This is important because both potentially could be used for organic fruit production. They also could be used in mixtures to prevent resistance of gray mold to fludioxonil in packinghouses using conventional treatments. Fludioxonil is currently the only highly effective gray mold material used commercially where no resistance has been found. Thus, its activity needs to be protected with registration of additional materials.

Fig. 7. Effect of application timing after inoculation on the efficacy of postharvest treatments with polyoxin-D and N-1 for management of blue mold and gray mold in laboratory studies



Fruit were inoculated with conidia of a TBZ-resistant isolate of *Penicillium expansum* or with *B. cinerea* (10^5 conidia/ml each) and were incubated for selected times at 20C. Treatments with aqueous fungicide solutions were done using a hand-sprayer. Fruit were then incubated at 20 C for 6 days.

Systems-based strategies for postharvest insect control: Mortality and removal of light brown apple moth, codling moth, brown marmorated stink bug, and other insect pests in California apples during packing and export

October 28, 2014

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Executive Summary.

An overall metric of treatment efficacy was developed, via combining the individual contributions from preharvest and postharvest processes, to evaluate systems-based strategies for insect control in fresh commodities, including apples. Systems-based strategies have potential overcome trade barriers for export of apples and will reduce the amount of chemical used to control an insect pest.

Background.

The detection and elimination of insect pests is necessary to ensure the safe movement of agricultural commodities from infested to non-infested areas through marketing channels. All treatments are subject to both regulatory and market-driven concerns, including commodity value. A treatment that is acceptable today may not be acceptable in the future. Over the last 20 years a framework based on biology was developed to assess and mitigate the risk posed by insects. This “systems approach” (Jang et al. 2006; Jang 1996; Jang and Moffitt 1994; Vail et al. 1993; Moffit 1990) was developed largely to support risk-assessments and mitigations that could occur in a broader based “system” of activities that cumulatively meet the quarantine requirements of the importing country. This approach provides both a framework for harmonizing risk assessment and mitigation, as well as a forum for oversight when disagreements exist (FAO 2011). We have expanded on this work via a toxicological-based approach where each event of protection, beginning in the field and ending at the point of sale, can be combined into a quantitative metric of insect control in order to meet the requirements of quarantine security.

Results and Discussion.

Research was conducted to quantify the control of key apple pests in various segments of the “system”, which includes production, packing, and shipping. Approaches for quantifying the cumulative effect of multiple events in a system on pest control (or risk associated with no control) have been limited to those instances when low prevalence of the pest in the field has been quantified. The proposed research provides a means for such quantification when low prevalence does not exist, as events are considered retrospectively from the final postharvest treatment event.

Using the general rule for the multiplication of probabilities (Rosenthal 1978; Finney 1948) on combining results (probabilities) of independent events, data from respective events were combined to quantify the cumulative effect of consecutive events on the “systemic” joint probabilities of control. For each event, the observed likelihood (expressed as a percentage) of finding a live insect, the theoretical percentage of mortality calculated at the 95% level of confidence (LOC) by the method of Couey and Chew (1986), and the associated probability, $P(E_x)$, could be tabulated. The Probit values at the 95% LOC and the confidence interval associated with Probit 9 treatment efficacy were calculated for each event as described in Liquido and Griffin (2010). In the case where one event, E_1, had no effect on the probability of the other(s), the joint probability of mortality associated with multiple treatment events, $P(E_{1+}E_{2+}En)$, was calculated from the multiplication of the simple probability of each event (Finney, 1948):

$$P(E_{1+}E_{2+}En) = 1-(1-P(E_1))(1-P(E_2))(1-P(En)) \text{ (Eq.1).}$$

Given equation 1, the special multiplication rule for independent events, the probability of insect mortality following the joint occurrence of two or more treatment events was calculated for any combination of events to meet (or supersede) control efficacies > 99.9968%, a statistical benchmark of phytosanitary treatment efficacy (Follet and Neven 2006; Couey and Chew 1986). An alternative approach to calculating the joint probability of multiple treatments, $P(E_b|E_a)$, involves multiplying the simple probability of the first event times the conditional probability of the second event, E_b, given the first,

$$E_a : P(E_b|E_a) = \frac{P(E_a \text{ and } E_b)}{P(E_a)} \text{ (Eq. 2).}$$

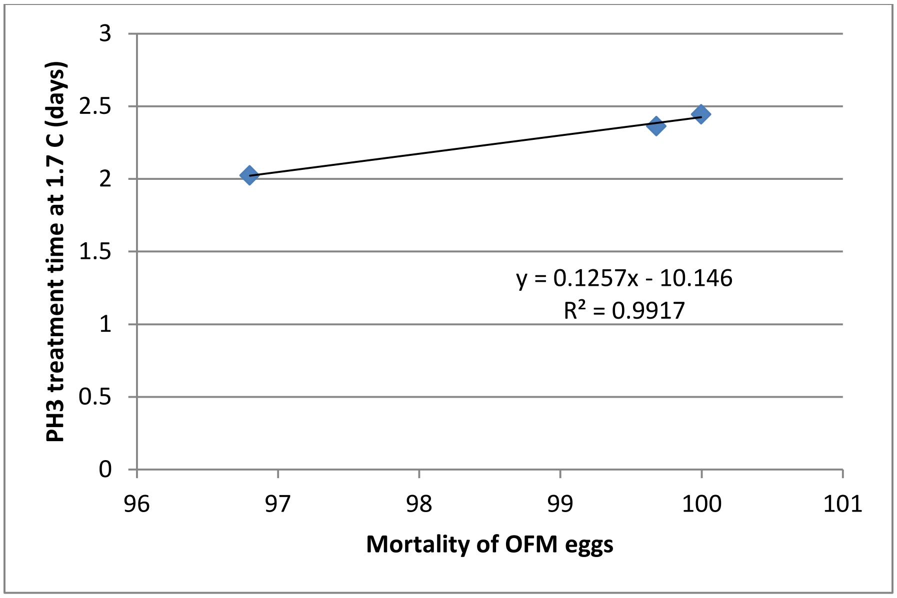
It is critical to note that even greater mortality is expected if a pair or series of events was evaluated conditionally (equation 2) versus independently (equation 1), because treatment survivors often are not fully healthy and are more susceptible to the subsequent treatment (Finney 1948).

Last year (Walse 2013 final report), we applied these models to the control of brown marmorated stink bug (BMSB) control on apples. Results can be used to support APHIS risk assessments and negotiations with foreign governments regarding BMSB-related phytosanitary issues. The research should enable The California apple industry to retain key export markets without a need for fumigation if BMSB is detected in production areas. Several series of postharvest events typically employed by California industry are highlighted and yield removal/mortality efficacies > 99.9968%, a statistical benchmark of phytosanitary treatment efficacy. This research can be provided to regulators and trading partners to quantify the reduction in risk/threat of BMSB as apples move from production areas through packing operations toward export markets.

Last year we also developed a mathematical model that predicted fumigations at 1.7 ± 0.5 °C ($\bar{x} \pm s$) with 1.5 mgL^{-1} (1000ppmv) required ~3 d treatment times for "quarantine" control of OFM eggs (i.e., ≥ 99.9986% mortality) per the equation:

$$\ln(y + 0.01) = 3.67 + 2.2x_1 - 2.6x_1^2 - 1.15x_2 - 0.26x_2^2 + 1.35x_1x_2 \quad \text{(Eq. 3)}$$

which is graphically depicted below.



Importantly, a 2-d treatment under these conditions is needed to control OFM larvae (Walse 2014 final fumigation report). If we are able to confirm 96.8% mortality of 10,000 OFM eggs following a 2-d fumigation at 1.7 ± 0.5 °C ($\bar{x} \pm s$) with 1.5 mgL^{-1} (1000ppmv) PH_3, as the equation 3 predicts, than we can use equation 1 or 2 above to estimate the probability of removing OFM eggs during packing that is needed to demonstrate that industry achieves Probit 9-level control (99.9986% mortality). Of course this will only be necessary should the egg life stage ever occur, or be considered to occur, in the marketing channel. If we assume that 300,000 boxes annually are shipped to export partners concerned with OFM, industry only needs to demonstrate that < 300 or < 310 OFM eggs enter the export marketing channel annually based on solving equation1 or 2, respectively.

County inspections for OFM support this assumption. Moreover, research was conducted to record the occurrence of OFM eggs entering a packing line to estimate the number of OFM eggs, given a two-leaf box tolerance (3.5g leaf per box), which are shipped in the 300,000 export boxes. For the past three years we have collected 750 lbs/year (wet weight) (340 kg) of leaf litter grated from packing lines, inspected the litter for OFM eggs, and incubated the litter under optimal rearing conditions for OFM. We have recorded two eggs, only one of which successfully hatched into a neonate, which translates into 0.002 OFM eggs/kg leaf. Based on the above logic, 2.1 OFM eggs can be expected in the 300,000 export boxes, more than 100-fold lower than what is needed to prove that OFM eggs could be controlled at a Probit-9 level of security following a postharvest fumigation with 1.5 mgL^{-1} (1000ppmv) PH_3 for 2 d at 1.7 ± 0.5 °C ($\bar{x} \pm s$).

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Postharvest treatment of California apples with cylinderized phosphine to control Oriental fruit moth (OFM), *Grapholita molesta*

October 28, 2014

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Executive Summary.

A new postharvest treatment option to control OFM has been developed for California apple growers/packers. Packed-boxes can be fumigated at cold-storage temperature for 48 h. A report can now be drafted and presented to industry (and thereafter APHIS) for consideration. Currently, market options include those countries willing to fumigate with phosphine on arrival (e.g., Chile, Australia). ARS is working with industry and USEPA to gain registration for PH3 so that fumigations can be done at the packinghouse.

Abstract.

Oriental fruit moth (OFM), *Grapholita molesta* (Busck) is a pest of concern to countries that import apples from California. Fruit were infested with OFM larvae (97% 5^{th} instar), buried amongst uninfested fruit in export cartons, and then the cartons were fumigated with PH3 at 1.7 ± 0.5 °C ($\bar{x} \pm s$). Fumigations resulted in 0 survivors from 9,965 (*n*) treated OFM larvae (probit 8.43, 95% level of confidence) when headspace concentrations were maintained at levels ≥ 1.5 mgL^{-1} (1000ppmv) phosphine (PH3) for 48 h. Data is discussed in the context of quarantine control of OFM following cylinderized PH3 fumigation of commercial apple exports.

Materials and Methods.

Insects and infestation. OFM colonies originated from wild specimens captured in Fresno County, California USA. OFM was cultured as described in Yokoyama et al. (1987) and USDA (2010). Larvae were extracted for fruit infestation 14-15 days after neonates were placed on diet contents in rearing cups. Fourth (0.425-0.600mm) and fifth (0.725-0.825 mm) instar head capsule widths, were typically extracted from the respective colonies for fumigation. To simulate naturally occurring OFM infestation, apples were cored with a #4 cork borer at 6 equidistant points, equatorially around the fruit, and predominantly 5^{th} instar specimens (97%) were placed at the center, near the core, of each cavity. Larvae were sealed into the fruit by inserting a fruit plug, created with a #5 cork borer, until flush with the fruit skin.

Confirmatory export fumigations. To simulate a commercial scenario, fumigations were conducted using 241.9-L steel chambers housed in a walk-in environmental incubator with programmable temperature and humidity (USDA, 2010). The chamber was first loaded with six 0.5 ft^3 sand bags each wrapped in plastic packaging that displaced ~84.9 L total of chamber volume. On the same day that they were packaged for export, two volume bushels (17.2 kg/carton, ct 113) of tray-packed "Granny Smith" apples (50.8 x 32.5 x 30.5 cm, 50.4 L each) were obtained from commercial wholesale sources in California. Fruit (~75) were removed from each of two cartons, infested as described above, transferred back into the respective cartons, and the cartons were loaded into a chamber. The chamber load was estimated as a fractional percentage, 64.2 ± 0.8% ($\bar{x} \pm s$), of the volume occupied by the load relative to the chamber volume (i.e., $V_L\ (V_{chamber})^{-1}$ x 100) (Monro, 1969).

Chambers loaded with test specimens and uninfested fruit as well as control specimens were acclimated to fumigation temperature of ~1.7 °C (~35.1°F) for 12 h prior to treatment (i.e., tempered) within the incubator described above. Fruit pulp temperature was confirmed prior to fumigation by each of three probes (YSI scanning tele-thermometer) that recorded the respective pulp temperature in three uninfested fruit distributed at different locations within the load of the fruit undergoing treatment. Temperature probes were then removed and chamber lids clamp-sealed in preparation for treatment. The chamber ventilation valve was opened and chambers were filled with a volume of fumigant from a cylinder of 1.6 % (v/v) PH3 balanced with nitrogen (Cytec Canada, Inc., Niagara Falls, Ontario, Canada) to achieve the requisite dose of 2.2 mgL^{-1} (1500 ppmv) as predetermined in preliminary calibration studies. The valve was then closed which marked the beginning of the exposure period. Gas samples (40 mL) were taken from the chamber headspace through a LuerLok® valve using a B-D® 100 mL gas-tight syringe and quantitatively analyzed for PH3 with GC-PFPD at standard intervals corresponding to 5 (initial), 60, 480, 1440 (1-d end), or 2880 (2-d end) min. Fumigant exposures were expressed as concentration × time cross products, "CTs", and calculated by the method of Monro (1969).

After completion of the fumigation, chamber valves were opened to atmosphere and vacuum was pulled to aerate the chamber until headspace concentration of the fumigant was below the mandated ventilation requirements of 0.3 ppm (0.45μg/L) phosphine. Chamber lids were opened, the treated and non-treated control specimens were collected, and then transferred to an incubator at 27.0 ± 1.0 °C and 80 ± 2% RH ($\bar{x} \pm s$).

Mortality evaluation. One day following fumigation, larval specimens were retrieved from treated and untreated controls and placed in a plastic dispo-Petri® dish lined with a filter paper for evaluation. Mortality was diagnosed visually by discoloration, while survivability of larvae was diagnosed by locomotion or by prodding-induced motion. Larvae were categorized as moribund if the survivability was inconclusive. Moribund larva were placed inside a labeled plastic snap-cap cage with fruit plugs to provide substrate and moisture prior to incubation under the conditions above until additional evaluation the following day. For the confirmatory trials, Abbott's method (1925) described by Finney (1944 and 1971) was used to estimate the percentage mortality of larvae used in Probit calculations, as the mortality of control specimens was assumed to be equal to that in fumigation trials. The total number of specimens that were treated for each exploratory- or confirmatory-trial was estimated by summing the numbers treated, while the total number of specimens treated (*n*) across confirmatory-trials was estimated by summing the numbers from each respective trial.

Chemicals and chemical analysis. A 300-lb cylinder of 1.6 % (v/v) PH3 balanced with nitrogen was obtained from Cytec Canada, Inc. (Niagara Falls, Ontario, Canada) and used as the source for gas chromatography calibrations as well as fumigations. PH3 levels in headspace of fumigation chambers were measured using gas chromatography; retention time (PH3, $t_r = 3.2 \pm 0.2$min) was used for chemical verification and the integral of peak area, referenced relative to liner least-squares analysis of a concentration – detector response curve, was used to determine concentration (Walse 2012 & 2013). Detector response and retention indices were determined each day in calibration studies by diluting known volumes of known concentrations of PH3 into volumetric gas vessels. PH3 analyses were with a Varian 3800 and splitless injection (140 °C) using a gas sampling port with a 10 μL-sample loop, a Teflon column (L = 2 m, OD = 2 mm) packed with Porpak N (80/100 mesh) held at 130 °C for 10 min, and a PFPD detector (13 mL/min H_2, 20 mL/min air, and 10.0 mL/min N_2 make-up) at 250 °C that received only 10% of the 15 ml He/min column flow.

Results and Discussion.

***Confirmatory export fumigations*.** Confirmatory PH3 fumigations of commercially-packaged apples were conducted in the context of verifying control of OFM larvae, the life stage with potential to be in postharvest marketing channels (Yokoyama et al. 1987). PH3 fumigations at 1.7 ± 0.5 °C ($\bar{x} \pm s$) with headspace concentrations maintained at levels ≥ 1.5 mgL^{-1} (1000ppmv) for 48 h resulted in > 99.969% mortality of OFM larvae (probit 8.43 at 95% level of confidence (LOC), probit 9 at 27% LOC) based on 0 survivors from 9,965 (*n*) treated as calculated by the method of Couey and Chew (1986) and Liquido and Griffin (2010) (Table 1). It is important to note that demonstrating 99.9968% (i.e., Probit 9 at the 95% LOC) mortality of quarantine insect pests is often requested to qualify phytosanitary treatment efficacy, particularly when commodity is moved internationally (Couey and Chew, 1986; Follet and Nevin, 2006).

Headspace concentrations of PH3 in commercial chamber fumigations of palletized fresh produce at load factors ≤ 65%, regardless of produce and packaging type, lose ~ 200 ppmv from chamber headspace per day (due to leakage, reactivity, and/or residue formation). Therefore, in the context of commercial considerations, observation of Probit 9-level mortality of OFM larvae in commercial PH3 fumigations lasting at least 48 h will likely require a single compensatory applied dose > 2.2 mgL^{-1} (1500 ppmv), or alternatively, maintenance of steady-state headspace concentrations ≥ 1.5 mgL^{-1} (1000ppmv) via multiple (daily) applications.

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Table 1. Complete control of 9,965 OFM larvae resulted from fumigation of infested apples with 2.2 mgL^{-1} (1500ppmv) phosphine for 48 h at 1.7 ± 0.5°C ($\bar{x} \pm s$).

Trial	# treated OFM	Applied (mg/L)	Applied (ppmv)	[PH3] at 48h (ppmv)	Temp. (±0.5 °C)	Temp. (±0.8 °F)	survivors	Abott's mort.	Probit (95% LOC)
1	842	2.2	1500	1020	1.7	35.1	0	1.00	7.69
2	851	2.2	1500	1127	1.7	35.1	0	1.00	7.70
3	904	2.2	1500	1058	1.7	35.1	0	1.00	7.72
4	821	2.2	1500	1073	1.7	35.1	0	1.00	7.68
5	863	2.2	1500	1086	1.7	35.1	0	1.00	7.70
6	874	2.2	1500	1045	1.7	35.1	0	1.00	7.70
7	754	2.2	1500	1196	1.7	35.1	0	1.00	7.66
8	898	2.2	1500	1038	1.7	35.1	0	1.00	7.71
9	752	2.2	1500	1102	1.7	35.1	0	1.00	7.65
10	847	2.2	1500	1053	1.7	35.1	0	1.00	7.69
11	695	2.2	1500	1049	1.7	35.1	0	1.00	7.63
12	864	2.2	1500	1012	1.7	35.1	0	1.00	7.70
	Σ 9,965 (*n*)						Σ 0		Σ 8.43

The postharvest fumigation of California blueberries to eliminate insects with potential to serve as export trade barriers *

Work group / Department: USDA-ARS-SJVASC, Crop Protection and Quality Unit

Project Year: October 31, 2014 Anticipated Duration of Project: Year 2 of 2

Project Title: The postharvest treatments of California blueberries to eliminate insects with potential to serve as export trade barriers

Principle Investigator: Spencer S. Walse

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*The postharvest fumigation of California blueberries to eliminate insects with potential to serve as export trade barriers final research report was under final review as of the time this annual report was published. A copy of the final report will be sent out after completion. If there are any further questions, please contact the Commission office.

CALIFORNIA APPLE COMMISSION
FUTURE RESEARCH 2014-2015

On May 2, 2014, the Research Committee for the California Apple Commission discussed current and future research projects. Two projects were recommended for extension to the Board of Directors for approval for the 2014-2015 season. All of the projects are a continuation of 2013-2014 season. These projects include:

1) *Evaluation of new bactericides for control of fire blight of apples caused by Erwinia amylovora and evaluation of new postharvest fungicides for pome fruits* - Dr. Jim Adaskaveg

2014/2015	**Amount**
Jim Adaskaveg- Evaluation of Bactericide…	$ 16,000[1]
FISCAL IMPACT FOR 2014/2015:	$ 16,000

Complete research projects and completed research thus far are included within this report.

[1] Research report amount will also increase with inclusion of organic Fireblight research by approximately $6,000.

AES/CE MAR 84

Workgroup: Apple
Department: Plant Pathology/UCR

University of California
Division of Agricultural Sciences
PROJECT PLAN/RESEARCH GRANT PROPOSAL

Project Year: 2014 Anticipated Duration of Project: 3rd year of 4 years

Principal Investigators: J. E. Adaskaveg
Cooperating: D. Thompson, D. Cary, and H. Förster

Project Title: Evaluation of new bactericides for control of fire blight of apples caused by *Erwinia amylovora* and evaluation of new postharvest fungicides for pome fruits

Keywords: Chemical and biological control

JUSTIFICATION/ BACKGROUND

Epidemiology and management of fire blight. Fire blight, caused by the bacterium *Erwinia amylovora*, is one of the most destructive diseases of pome fruit trees including apples. The disease causes a blackening of twigs, flowers, and foliage and is indigenous to North America but has since spread worldwide. In addition to cankers, the pathogen overwinters in flower buds, diseased fruit, small twigs, and branches. In the spring, blossoms are infected through natural openings in nectaries and pistils. After destroying the blossom, the bacteria spread into the peduncle, spur, and twig. During warm, humid weather, ooze droplets consisting of new inoculum are exuded from the peduncles and other infected tissues. Inoculum is spread by wind, rain, insects, birds, or by man, e.g., by means of contaminated pruning tools. Secondary infections may occur throughout the growing season.

Current chemical control programs for fire blight control are based on protective schedules, because available compounds are contact treatments and are not systemic. Control with conventional copper compounds is only satisfactory when disease severity is low to moderate. These treatments are only used during dormant and bloom periods because phytotoxicity commonly occurs on fruit as russeting. To date, there is no copper resistance in pathogen populations. Antibiotics for blight control include streptomycin and the less effective oxytetracycline (Mycoshield, Fireline) that both target sites in the protein biosynthesis pathway of the pathogen. Others have indicated that the latter antibiotic is not persistent and degrades under UV light and rainfall in short periods of time (Christiano et al. 2009, Plant Disease 94:1213-1218). Pathogen resistance against streptomycin is widespread in California. We characterized streptomycin resistance in current California populations of the pathogen on a molecular base. We found that the same resistance genes are involved as described from other locations, however, these genes are located on a different plasmid that previously has not been reported to harbor streptomycin resistance anywhere else in the world. Thus, resistance in California populations of *E. amylovora* is based on a novel mechanism of the pathogen. Additionally in recent years, we detected isolates of *E. amylovora* with reduced sensitivity to oxytetracycline at four California locations. At one of these locations, field treatments with oxytetracycline were reported to be ineffective in controlling the disease and thus, field resistance has occurred in some locations. Furthermore from a regulatory perspective, streptomycin and oxytetracycline are currently being removed from the approved list of organic treatments of apples and pome fruit by the National Organic Standards Board (NOSB). Thus, organic growers will have only limited choices for disease control strategies.

New materials for fire blight control need to be developed for organic and conventional growers in order to practice resistance management and to ensure resistance to oxytetracycline does not spread in the pathogen population. Furthermore, the incidence of resistance against streptomycin can possibly be reduced if more rotational treatments are available, making this important management tool more effective again. Our survey data on streptomycin resistance in the pathogen population indicated a direct correlation of high incidence of resistance with high-disease occurrence (e.g., 2007, 2009, and 2011). As previously described and modeled by several researchers, incidence of disease is directly related to favorable environments, namely warming temperatures during the bloom. Rainfall and insects exacerbate disease development. Although the incidence of resistance decreased in years of low disease occurrence, our data indicate that isolates resistant to streptomycin appear to be fit and the resistant pathogen population is stable in locations that were repeatedly sampled over different seasons.

An ideal material should be effective, locally systemic, not be phytotoxic, should target multiple sites of action within the bacterial pathogen, and have a mode of action different from currently used bactericides. Materials with different modes of action could then be incorporated into a resistance management program. In our previous research, we evaluated a wide-range of materials. Kasugamycin was the material selected with the highest efficacy and registration potential. Kasugamycin is known to have high activity against bacteria, including species of *Erwinia* and *Pseudomonas*, and has some activity against *Xanthomonas* spp. Kasugamycin is not being used in human and animal medicine. Kasugamycin has a different mode of action from streptomycin or oxytetracycline and there is no cross-resistance known to occur. Federal and state registrations are pending in 2014. Rates of the antibiotic, application volumes, and performance in rotations or mixtures with other antibiotics and fungicides have been evaluated. We also established the *in vitro* baseline sensitivity for kasugamycin using over 400 isolates of *E. amylovora*. All isolates showed a similar level of sensitivity.

In more recent research to complement antibiotics, the fungicide Quintec, presumably functioning as an SAR material, showed efficacy in combination with Kasumin. Other new systemic acquired resistance or SAR materials that deserve continued evaluation include Actigard and PM-1. These products have been shown to activate the plant's defense system through the production of phytoalexins or certain pathogenicity-related proteins that are non-specific defense chemicals. Possibly these compounds can be used in combination with other bactericides to enhance their efficacy. Furthermore, SAR compounds may have a longer lasting effect on the plant's defense activation. SAR research should continue as a supplemental program to a program based on bactericides.

New copper products that are re-formulated with reduced rates of metallic copper equivalent (MCE) and less contamination in their formulation that may cause phytotoxicity have been developed and are now available. These products need to be evaluated and tested for extended usage past the bloom period to determine if an effective mixture or rotational program with other bactericides can be developed without causing fruit russeting. Combinations of kasugamycin and selected copper products were tested in 2012 and 2013 and shown to be effective in some trials and less effective in other trials. Still only a few products were tested (Badge X2 and Kocide 3000) and newer copper products are now being marketed in the United States. These include CS-2005 (Magna Bon, Inc.) and Previsto (Gowan Co.) that have reported efficacy without phytotoxicity. Thus, this research needs to be continued especially if antibiotics are no longer OMRI listed and organically approved.

In trials with biocontrols, Blossom Protect (*Aureobasidium pullulans*) was evaluated for the last several years and shown to be highly effective and one of the most consistent biologicals that we have evaluated. Actinovate (*Streptomyces lydicus*) also showed promise in some trials especially at low rates and in combination with a sticker adjuvant. Thus, our recent research on organic alternatives is quite promising. Biological controls that have been developed for fire blight in the United States include the registered Blight Ban A506 Biopesticide (*Pseudomonas fluorescens* strain A506), Serenade (fermentation product of *Bacillus subtilis* strain QST 713), as well as Bloomtime Biological FD Biopesticide (*Pantoea agglomerans* strain E325). Unfortunately they have been very inconsistent in their performance. These products are most effective under low inoculum levels and less favorable micro-environments. Thus, among biologicals Actinovate, Blossom Protect, and the newly registered product Double Nickel 55 (*Bacillus amyloliquefaciens*), should continue to be evaluated in 2014 in combination or rotation with new copper materials. The toxicity of antibiotics or copper used in fire blight control against new biocontrols has demonstrated selective incompatibilities and the testing needs to be extended among the biologicals and other products (e.g., antibiotics, copper formulations, etc.). Incompatibilities could prevent the use of biocontrols in rotations or application tank mixtures.

Our goal is to develop highly effective rotational programs for either organic farming practices with the use of copper and biologicals or conventional practices with the use of antibiotics alone or in mixtures with fungicides, copper, biologicals or potentially SAR compounds during bloom or as cover sprays during early fruit development. With the detection of isolates of *E. amylovora* with reduced sensitivity to oxytetracycline, the yearly fluctuations in incidence of streptomycin resistance, and the potential loss of efficacy of biologicals, we will need to continue monitoring programs, as well as conduct molecular characterization of resistant strains.

We are also planning to explore a new strategy for the management of fire blight that includes the use of novel chemistries that inhibit membrane function and possibly increase the activity of metallic cations such as copper or zinc. Several materials are available and include products coded as CTz and ZTz (registrant anonymity).

Thus, we plan to evaluate membrane disruptors in combination with low MCE compounds, antibiotics (e.g., Kasumin), and other products in mixtures or rotations to optimize in-season applications.

Management of postharvest decays. Apples like other pome fruit can be stored for some period of time using the correct storage environments. Still, postharvest decays caused by fungal organisms can cause crop losses that are economically detrimental to storing and marketing of fruit. The major postharvest pathogens of apples include *Penicillium expansum*, *Botrytis cinerea*, *Alternaria alternata*, *Mucor piriformis*, and *Neofabraea* spp. causing blue mold, gray mold, black mold, Mucor decay, and bull's eye rot, respectively. Thiabendazole (TBZ) has been the main postharvest fungicide available for pome fruit for the last 35 years. Unfortunately, with extensive usage, TBZ-resistant populations of *Penicillium* and *Botrytis* spp. have developed and are commonly found in packinghouse storage rooms.

Although fungicides can reduce the incidence of decay when used preharvest, they are most effectively used as postharvest treatments. Through our research, new postharvest fungicides that were registered in recent years include the phenylpyrrole Scholar (fludioxonil) and the anilinopyrimidine Penbotec pyrimethanil), that are both effective against gray mold and blue mold, as well as the hydroxyanilide Judge (fenhexamid) that is only effective against gray mold. Like TBZ, these are all single-site mode of action fungicides that have a high risk for selecting for resistant pathogen populations when used exclusively. Unfortunately, this practice is often the case because pricing and marketing of fungicides with other postharvest treatments (e.g., sanitizers, fruit coatings) are major factors for packinghouse managers. We are continuing our evaluation and support of registration of new materials because not all of the fungicides have the same spectrum of activity against the various decays occurring on pome fruit. Additionally, there is widespread resistance against TBZ in *Penicillium* and *Botrytis* populations. More recently, resistance to pyrimethanil has been reported in both pathogens in packinghouses in the Pacific Northwest. Our laboratory studies also predicted a high resistance potential for pyrimethanil, but also for fludioxonil, and some of the resistant isolates competed well in the presence of sensitive wild-type isolates. Thus, new materials of different chemical classes are needed to combat resistance development.

In collaboration with the registrant of Scholar, Syngenta Crop Protection, and IR- 4 Specialty Crop Program, over several years we have been evaluating the DMI fungicide difenoconazole as a mix partner for fludioxonil. Difenoconazole is not effective against gray mold, but highly effective against blue mold and also bull's eye rot (that is not controlled with fludioxonil). In fruit inoculation studies in 2013, we demonstrated the efficacy of the mixture of both fungicides to extend to *Alternaria* decay, bitter rot, and Bull's eye rot. We have been successful in optimizing usage rates and evaluating several pre-mixture formulations, and these studies need to be repeated and finalized. Registration for difenoconazole is expected in the summer of 2014.

In initial studies in 2012, we found that polyoxin-D (Ph-D) was similarly effective to Penbotec in reducing the incidence of gray mold, but it was not effective against blue mold. In 2013, we showed that this compound and another one called N-1 are also highly effective against *Alternaria* species. Also, N-1 shows moderate efficacy against decays caused by *Penicillium*, *Botrytis*, and *Mucor* spp. Polyoxin-D and N-1 have an exempt registration status and thus, both have the potential to be effective organic treatments if they become certified by the NOSB. Our goal is to continue to evaluate these products for the management of postharvest decays of apples. The registrants of these fungicides are supporting the development on fruit crops and are planning to submit for registration. N-1 has been used as a food additive to prevent mold growth, including *Penicillium* species, on dairy products for many years in the United States. Over all the years in use, resistance in *Penicillium* species against N-1 has not occurred. Thus, we plan to evaluate these very exciting new products for the management of postharvest decays of apples.

Objectives for 2014

Fire blight research

1. Evaluate the efficacy of treatments for managing fire blight and characterize antibiotic resistance.
   - A. Laboratory in vitro tests to evaluate the bactericidal activity of antibiotics or copper products with and without membrane disruptors such as CTz or ZTz using spiral gradient dilution assays.
   - B. Small-scale hand-sprayer tests using different treatment-inoculation schedules to evaluate membrane disruptors in combination with antibiotics and/or low MCE copper products.
   - C. Field trials with protective air-blast spray treatments:

i. New formulations of copper (e.g., Kocide 3000, CS 2005, Cueva, and Previsto) with and without antibiotics.
ii. Plant defense activators (e.g, Actigard, PM-1) with and without antibiotics.
iii. Evaluate the efficacy of biological controls (e.g., Actinovate, Blossom Protect, Double Nickel 55) in integrated programs using antibiotics and low MCE copper products.

Postharvest research

2. Comparative evaluation of new postharvest fungicides
   A. Evaluate difenoconazole, fludioxonil, and difenoconazole-fludioxonil pre-mixtures at selected rates against gray mold, blue mold, Alternaria decay, and bull's eye rot and compare to pyrimethanil.
   B. Evaluate polyoxin-D and N-1 against gray mold, Alternaria decay, and bull's eye rot and compare to pyrimethanil and fludioxonil.
   C. Determination of baseline sensitivities. Baseline sensitivities for N-1 and polyoxin-D and other fungicides will be continued to be developed for additional fungal pathogens that are collected.

Plans and Procedures

Evaluation membrane disruptors such as CTz or ZTz as toxicants with or without antibiotics or copper to* E. amylovora *in laboratory assays and small-scale field trials. Strains of *E. amylovora* that are sensitive kasugamycin, sensitive or resistant to streptomycin (high and moderate resistant strains), and sensitive or resistant oxytetracycline will be evaluated for their sensitivity to each of the three antibiotics or copper products with or without the addition of CTz or ZTz membrane disruptors. For determination of the in vitro sensitivity, we will use the spiral gradient dilution assay where a chemical concentration gradient is established on nutrient agar in a Petri dish. Suspensions of *E. amylovora* will be plated onto the medium in radial streaks across the concentration gradient. Inhibitory concentrations will be determined using a computer program.

In small-scale field tests in an experimental orchard, treatments using CTz or ZTz membrane disruptors in conjunction with antibiotics or copper products will be applied to run-off to open blossoms using a hand sprayer. Each replication will consist of one branch on each of four trees. After selected time periods, blossoms will be spray-inoculated with *E. amylovora* (10^6 cfu/ml), inoculated branches will be bagged overnight, and disease will be evaluated based on the number of diseased blossoms per 100 blossoms evaluated per replication. The post-infection activity of treatments will be evaluated by first inoculating blossoms and treating after 24 h.

Field studies on the management of fire blight using protective treatments during the growing season. Air-blast field studies on the relative efficacy of protective treatments will be conducted in an experimental apple orchard at the Kearney AgCenter where fire blight caused crop losses previously. Two applications will be done (at 10-20% and at 60-80% bloom). The relative efficacy of protective treatments of Kasumin (100 ppm) and selected SAR compounds such as Actigard and PM-1 will be used alone or in mixtures with antibiotics to evaluate the effect on efficacy and phytotoxicity. New copper formulations that use a reduced amount of copper including Kocide 3000 (0.5 lb/A), CS 2005 (150 ppm), and Previsto or Cueva (2 gal/A) will also be evaluated. The biological controls Actinovate, Blossom Protect, and Double Nickel 55 will be evaluated alone or in rotation/mixtures with other treatments to develop integrated programs for resistance management. Incidence of new blight infections on blossoms and leaves in addition to potential phytotoxic effects of the treatments (e.g., fruit russeting caused by copper) will be evaluated. Application timings will be determined based on temperature, rainfall, and host development. Treatments will be replicated four to six times on different trees. Data for chemical and biological control will be analyzed using analysis of variance and LSD mean separation procedures of SAS 9.1.

Efficacy of new postharvest fungicides for managing apple decays in storage. Fruit (cvs. Granny Smith and Fuji) will be treated similar to commercial practices concerning harvest, handling, packing, and temperature-management of fruit. Fruit will be wound-inoculated with conidial suspensions of several decay fungi (*B. cinerea, P. expansum, N. perennans, Alternaria* sp.) and treated after selected times. N-1 and the other fungicides (fludioxonil, difenoconazole, pre-mixtures fludioxonil/difenoconazole, and polyoxin-D) will then be evaluated in experimental packing line trials at Kearney Agricultural Center and 20-40 fruit for each of four replications will be used. For the new fludioxonil-difenoconazole pre-mixture, we will compare the efficacy of different application methods (in-line drench, CDA, and T-jet). Treatments will be compared to pyrimethanil. Data will be analyzed using analysis of variance and averages will be separated using least significant difference mean separation procedures of SAS 9.2.

Determination of baseline sensitivities. Baseline sensitivities for fludioxonil and difenoconazole as well as polyoxin-D and N-1 will be continued to be developed for apple pathogens that are collected with a goal of 70 isolates for each pathogen. We will use the spiral gradient dilution method that allows for efficient, high-throughput evaluation of isolates to determine EC_{50} concentrations.

Benefits to the industry

Fireblight research. Kasugamycin was registered in Canada in 2013 and with the approval of kasugamycin by the US-EPA in 2014, tolerances and MRLs for kasugamycin will be established on pome fruit, walnut, and tomato crops. With the limited number of materials available to pome fruit growers, this new active ingredient represents a major step forward for managing fire blight in an integrated approach before resistance develops in the pathogen population. Historically, the overuse of streptomycin led to resistant pathogen populations and the over-reliance of oxytetracycline as a substitute for streptomycin has led to the first detections of oxytetracycline resistance in the pathogen. Information from this research project will help to develop integrated programs for using kasugamycin in rotations or mixtures with other antibiotics, fungicides, biologicals, and possibly SAR compounds and new materials (e.g., membrane disruptors) that will hopefully minimize the risk for the development of resistant populations of the pathogen to this antibiotic, as well as any new material. The label of Kasumin 2L will include directions for 100 ppm usage rates (64 fl oz/100 gal/A) and up to 4 applications per season with no more than two sequential applications. The product label will include guidelines for optimal use (e.g., pH, buffers needed), suggested use with adjuvants, and use in rotation or combination with other available treatments.

With removal of antibiotics as treatments for organic production, research on organic alternatives including new formulations of copper and biologicals will help the organic segment of apple production. Research in this project has already identified biologicals with consistent and inconsistent performance. Newer biologicals (e.g., Actinovate, Blossom Protect) are consistent in performance and their usage with newer copper products will help the organic apple industry manage fire blight without antibiotics.

Postharvest decay management research. For the packer, the challenge is to develop management programs using new fungicides for control of gray mold, blue mold, Alternaria rot, and other decays of apple. The challenge to the industry is to store fruit and provide decay-free, wholesome fruit to local and distant markets. For this, fungicide management programs have to be developed and continually adapted for control of gray mold, blue mold, and other decays of apple based on new fungicides that are replacing or supplementing the previous postharvest standard TBZ (Mertect) and allow rotations and mixtures to prevent selection of resistance in postharvest fungal pathogens. The development of several effective postharvest fungicide treatments including materials that are exempt from tolerance, as well as pre-mixtures of new fungicides will improve performance and greatly decrease losses of fruit from various decays during storage in a durable program that will be effective for many years. Baseline sensitivities that we are establishing in pathogen populations will facilitate the early detection and prevent the spread of resistance. Another critical aspect of this research is improving the efficacy of each material using optimal application methods such as using postharvest re-circulating in-line drenches. Thus, information from this research directly benefits growers and packers by identifying and registering new materials, as well as development of improved application practices for control of postharvest diseases of apples.

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Budget Request:
Budget Year: 2014.
Funding Source: Apple Commission of California

Salaries and Benefits:	Post-Docs/RAs		5,000
	Lab/Field Ass't		2,500
	Subtotal		7,500
	Employees' Benefits		3,500
		Subtotal	11,000
Supplies and Expenses*			3,000
Equipment			0
Operating Expenses/Equipment Travel (Davis Campus only)			0
Travel			2,000
Department Account No. ________		**Total**	**16,000**

*** -** Costs include expenses of $2000 for maintaining an apple orchard at the Kearney AgCenter.

Originator's Signature J. E. Adaskaveg Date: 12-23-13

Department Chair Katherine Borkovich Date: 12-23-13

Liaison Officer ______________________ Date: ________

PESTS, DISEASE & STANDARDIZATION

PESTS, DISEASE AND STANDARDIZATION

Over the last few years, the Commission has been successful in obtaining grant dollars to address pest, disease, and standardization issues. These grants have included starch-iodine studies which assisted the Commission in reducing subjective maturity standards, as well as Technical Assistance for Specialty Crop (TASC), and Market Access Program (MAP) to assist in the inspection process for Mexico and Taiwan pest inspection programs.

In 2011, the California Department of Food and Agriculture agreed to the Commission's request and officially repealed the mandatory standard. As a result, the industry was able to harvest Granny Smith apples based on the market and not a subjective test.

In 2012, the California Apple Commission received an additional grant to study the economic impact of the removal of the starch iodine standard. Based on the results, and thanks to the California Apple Commission, the removal of the standard has saved the industry $18.7 million. Prior to the removal of the standard, it is estimated that the industry lost nearly $18.7 million or approximately $1 per box over the 13-year period.

In 2013, the Commission applied for a specialty crop block grant to assess the impacts of shade cloth on California apples. The Commission is pleased to announce that the industry was approved for this grant and began the program November 2014. The three year project will study the impacts of shade cloth on California varieties and how the cloth reduces sun burn, assists in the reduction of overhead cooling (in an effort to save water) and crop protection products and potentially assists in the improvement of apple color for marketing purposes. The Commission will continue to update the industry as this project moves forward.

CALIFORNIA APPLE EXPORT MARKETS

CALIFORNIA APPLE EXPORT AND DOMESTIC MARKET OVERVIEW

The California Apple Commission has culminated the final export numbers for the 2013/2014 season. California exported a total of 264,639 boxes. Out of the 15 countries that California exported to, most of them were at their normal or below averages. California is the second largest exporter of apples in the United States and actively receives Market Access Program dollars to help maintain these necessary export markets.

Last season, the Commission through the US Apple Export Council received $916,447.00 for the 2013/2014 program year and will receive roughly $1,104,764.00 for the 2014/2015 program year.

California receives several benefits from the overall funding as we are the largest exporter on the Council and participate in almost every export program. Below is a list of the top five countries and U.S. states that California shipped to this season. Enclosed is an overview of each market that receives MAP, TASC, or EMP funding, and all statistical shipping and destination information.

Top Five Countries		Top Five U.S. States	
1) Canada	(132,105)	1) California	(969,932)
2) Malaysia	(46,509)	2) Texas	(248,105)
3) Mexico	(31,184)	3) Washington	(59,851)
4) Sri Lanka	(11,680)	4) Illinois	(53,648)
5) Taiwan	(10,309)	5) Florida	(42,993)

FOREIGN AGRICULTURAL SERVICE

The Foreign Agricultural Service (FAS) helps expand and maintain foreign markets for US agricultural products by helping to remove trade barriers and enforcing U.S. rights under existing trade agreements. The FAS works with foreign governments, international organizations, and the Office of the U.S. Trade Representative to establish international standards and rules to improve accountability and predictability for agricultural trade. Additionally, FAS partners up with cooperators like the US Apple Export Council to help US exporters develop and maintain agricultural export markets. The FAS distributes funding to these cooperators via the Farm Bill under programs such as the Market Access Program (MAP), Technical Assistance for Specialty Crops (TASC), and Emerging Market Programs (EMP). All of these programs keep US products more competitive and counter subsidized foreign competition in the international market.

Due to the Sequester that took place in 2013, the California Apple Commission through partnering with the USAEC received $916,447.00 for the 2013-2014 season. Most, if not all, agricultural organizations received a reduced budget. This funding allocation covered 9 export markets, 6 of which California participated in. These monies funded programs such as the Mexico Inspection program, Taiwan Inspection Program, Import and Retail trade servicing within the export markets, Consumer Communication, Trade Missions, Education and Market Research. The overall allocation to the US Apple Export Council for the 2014-2015 program year was increased to $1,104,727.00.

CANADA

Canada is California's largest and most important market, comprising of almost 60 percent of California exports. In 2013-2014, California exported 132,105 boxes to Canada with the most popular variety being the Gala. The US Apple Export Council (USAEC) views Canada as a sustainable and viable market but with limited marketable access from all States. In 2013-2014, the USAEC contributed $132,000 to the promotion of US Apples in Canada. Since California is the primary exporter of apples to Canada, most of that funding is disseminated during the California season. In 2013, the USAEC representative in Canada, Ken Berger, visited California before the start of the California apple harvest. The purpose of the visit was to meet with the handlers intending on shipping to Canada and set up promotions with specified retailers in Canada. Throughout the season, the main goal of the USAEC in Canada is to try and have the retailers remain with California for slightly longer than they normally would. This can be achieved by convincing the Canadian retailers to switch from Southern Hemisphere fruit earlier and by having the Canadian retailers stay with the California handler for a little longer as Washington State begins their harvest. In 2013, the USAEC shifted the focus of the MAP funding being provided to emphasize quality and the early availability of California apples in an attempt to extend the California season. Initially, this program worked but ultimately price and volume from Washington State began to slow shipments from California.

In 2013, California Galas began arriving the last week of July and remained strong through most of August. Promotions and demos were timed to coincide with the arrival of California apples. The following targets and promotion were completed:

- Loblaw Companies: In-Store sampling of Granny Smith and Fuji varieties, supported by flyer ads in up to 50 stores and 4 banners across Canada
- Overwaitea Food Group: Flyer ad funding on Gala, Granny Smith and Fuji varieties in 4 banners
- Safeway: Flyer ad funding on Gala, Granny Smith and Fuji varieties
- Westcoast: Flyer ad funding on Gala, Granny Smith and Fuji varieties in 2 banners

The US and Canadian governments have been working together to set up new trade policies but with the introduction of new pests and diseases this could include a work plan. Fortunately, both governments want to streamline the trade process by eliminating the MRL differences and include known pest and disease similarities. In addition, recently the Farm Products Council of Canada proposed putting levies on imported strawberries. These levies and fees will be used to promote local strawberry production. Currently, a proposal has not been submitted for apples. The CAC has been actively involved in this area and will inform the industry of any changes.

The USAEC will assist the California Apple Commission in attaining $126,935 for the 2014-2015 season.

MEXICO

In the 2013-2014 season, California exported 31,184 boxes to Mexico. This is slightly below the previous year but nowhere near the high of 100,000 boxes in 2008. Due to the proximity and ability to import lower marketable fruit, the Mexico market continues to be a high priority market for both the California Apple Commission and the US Apple Export Council (USAEC). In 2013-2014, the USAEC committed $110,000 to help maintain the Mexican market. As in previous seasons, the number one variety being sent to Mexico is the Granny Smith apple. Mexico importers have demonstrated significant demand during the California season but due to the high domestic prices shipments to Mexico have been diminished.

Due to the increasingly defensive posture by the Mexican government, most funding is going directly to the Mexican Oversight Program. During the last season, the CAC, through funding received by the USAEC, spent close to $75,000 of the $110,000 budget on the Mexico Oversight Program. The CAC has been aggressively trying to remove or reduce the Oversight Program in California and has seemingly made progress for the upcoming season (2014-2015). The Mexican government has agreed to begin reducing the Mexico Oversight Program as long as there are zero findings for the 2014-2015 season. If all goes as planned and zero pests are found at the border, Mexico has agreed to reduce the Mexico Inspector by 50% in 2015-2016 and completely eliminate the inspector by 2016-2017. On paper this agreement seems amenable but unfortunately the CAC has yet to get a definition of what a 50% reduction means.

The USAEC will assist the California Apple Commission in attaining $138,000 for the 2014-2015 season.

SOUTH EAST ASIA

South East Asia (SEA) is a region that consists of Malaysia, Thailand, Indonesia, Singapore, Vietnam, and the Philippines. The SEA region is quickly becoming one of California's largest markets. The SEA market is classified as a region due to its clear marketing relationships and partnerships between retailers and wholesalers. With an overall population of 523 million and a middle class that is expected to double by 2025, the USAEC considers this a growth market with a high priority. The USAEC provided $135,000 dollars in MAP/EMP funding for marketing support in SEA. In 2013-2014 California exported 81,045 boxes to the SEA region, most of which was the Granny Smith variety.

Retail trends continue to remain unchanged in most of SEA. Although modern retail outlets are expanding into secondary cities and major towns throughout SEA, traditional retailers in the developed markets (Singapore & Kuala Lumpur) are shrinking. Due to proximity and price, China dominates the market but only among the Fuji variety. Major retailers within SEA (especially in the developed areas) are beginning to realize that to be competitive in the produce sector they should follow the structure established by the American retail market. This includes more varieties of apples, in well lit, upfront produce sections. The USAEC has been trying to capitalize on this notion by suggesting and introducing new varieties from States outside of Washington. These new varieties include Empire and Cripps Pink. For California, the main exported variety is still the Granny Smith. With the successful promotion of combining Peanut Butter and Granny Smith apples in Canada, the USAEC has discussed exploring a similar promotion campaign in SEA.

The USAEC will assist the California Apple Commission in attaining $199,500 for the 2014-2015 season.

INDIA

With India's massive population (250 million middle class population), it is quickly becoming one of the major importers of US apples. India is set to become the largest importer of apples in the world in the near future. Because of this, the USAEC has been using MAP/EMP/TASC funding to try and capture some of the opportunity. In 2013-2014, the USAEC contributed $126,667 to the developing market.

From a CAC perspective, the Indian market, although vast with potential, is more of a niche market. The logistics of shipping to such a far off destination is a very high risk and the volume of the varieties that California would ship would most likely not be pronounced. Although this will not be a market California focuses on, the USAEC is considering it a primary focus for the promotion and timing of varieties from other partner States within the USAEC. The SCS Group, the in-country trade representative for USAEC in India, is responsible for the following activities in the country:

- Planning and executing promotional activities
- Ensuring that the USAEC meets or exceeds its consumer and trade goals
- Submitting monthly status reviews to the USAEC
- Managing USA Apple affairs in India
- Keeping in constant contact with the trade
- Meeting with and assisting USA Apple growers and shippers while they are in India
- Distribute POS materials and Branded Display items

In conjunction with the SCS Group, the USAEC conducted a Reverse Trade Mission during September 13-17, 2013. This trade mission comprised of 7 Indian importers and visited primarily the East Coast with the final destination being PMA. The SCS Group also represented the USAEC in the Aahar 2014 trade show in New Delhi and the Fresh Produce India 2014 conference in Pune, India during the 2013-14 marketing year.

The USAEC India office also conducted in-store consumer promotion campaigns with 6 Food Hall stores in cities of Delhi, Mumbai, and Bangalore over a period of 15 days. Food Hall, dealing with premium and imported food is a part of the Future Group, India's biggest retail company. This promotion campaign was very successful in generating awareness about USA Apples among target Indian consumers and increased sales by approximately 40% during the promotion period.

During July 2013 till May 2014 (as per availability of data from FAS), the export volumes touched nearly 180,000 boxes with a value of US$ 4.18 Million, strengthening India's position as one of the fastest growing markets for USAEC. The above figure leads to a ROI of 32.25% during the 2013-14 marketing year.

The USAEC will assist the California Apple Commission in attaining $137,667 for the 2014-2015 season.

BRAZIL

With the World Cup being held in Brazil and the upcoming Summer Olympics, the USAEC anticipated Brazil to be a fast growing market with enormous potential. In 2012, the USAEC began making a push to utilize MAP dollars in Brazil with the intention of focusing primarily on Eastern US red varieties. Any promotional campaigns and marketing relied on the notion that a Systems Approach for the treatment of apples into Brazil would be agreed upon. Unfortunately, a Systems Approach was not agreed to and all promotional and marketing efforts were put on hold. The USAEC currently has a representative only, to maintain a presence in the market and to keep pressure on the Brazilian government.

If and when the treatment requirements are agreed to, the main competition for the US will be Southern Hemisphere stored apples and fresh apples from the European market. Europe currently enjoys a strong position in the Brazil market due to relatively low freight costs, favorable MRL tolerances, and close to zero tariffs.

The CAC does not consider Brazil a market of priority for California but does view it as a potential market for the Eastern US. Due to the current population and the growth of the middle class, if the Brazilian market can open with limited restrictions, the volume of apples exported from the US could significantly help ease the pressure on the domestic market.

The USAEC will assist the California Apple Commission in attaining $11,000 for the 2014-2015 season.

RUSSIA

Russia is still the world's largest importers of apples, importing roughly 1 million tons per year. From the US, most of these apples come from Washington State and enter through the Eastern port of Vladivostok. For California and the USAEC, Russia remains a low priority. Although Russia has demonstrated market potential, the logistics of shipping to Russia and the prices wanted are not attainable by most USAEC members.

In August 2014, due to political unrest between Russia and the West, Russia prohibited all imports from Europe and the US for 1 year. This will have a tremendous effect on the world apple market considering Washington State alone exported close to 12 million boxes to Russia. Consequently, all apples from the West and Europe that would normally go to Russia will now be in other markets.

The USAEC will maintain an in-country representative but all promotion and marketing activities will be terminated until the constraints have been lifted. The Commission anticipates that the export restrictions will be lifted by the 2015-2016 California apple season.

The USAEC will assist the California Apple Commission in attaining $5,000 for the 2014-2015 season.

CENTRAL AMERICA

In 2013-2014, the USAEC began increasing activities in Central America. For the USAEC marketing program, the Central American market consists of Guatemala, Costa Rica, El Salvador, Honduras, Panama, Nicaragua, and the Dominican Republic. Over the last several years, Central America has become increasingly important to Michigan and the Eastern US. Due to the proximity of Central America and their willingness to purchase smaller sized fruit, the market has been increasingly attractive to many Eastern shippers.

The in-country representative, Groupo PM, divided the 2013-2014 program into two sections: trade activities and consumer oriented activities. As part of the trade activities, Groupo PM oversaw the trade servicing, merchandising, and activities performed by the merchandising team with one merchandiser covering each market. This team gathered market information, delivered POS materials, and was in daily contact with the retailers and importers within each market. The consumer oriented activities included educational materials, POS materials, and in-store sampling. This allowed Groupo PM to reach out to the consumer and demonstrate a consistent message about the benefits of US apples. In October 2013, the USAEC hosted a Reverse Trade Mission to the Eastern US. The purpose of this mission was to introduce Central American importers during the beginning of the Eastern US season so that they could see the quality and the varieties being offered.

Over the last several seasons, Central America has become less of a priority to California due to the domestic market prices being extremely strong. Unfortunately, the demand for California apples in Central America is clearly evident but the unwillingness of importers to meet the price demands of California exporters has extremely limited the exports. With market fluctuations, Central America could once again be relied upon to take some of California's low-end fruit and therefore the CAC will continue to support program activities.

The USAEC will assist the California Apple Commission in attaining $103,625 for the 2014-2015 season.

CALIFORNIA APPLE DOMESTIC AND EXPORT STATISTICS

CALIFORNIA APPLE COMMISSION

DOMESTIC & EXPORT REPORTS
2013 – 2014 SEASON

- **California Domestic Apple Statistics**
- **California's Top 5 States**
- **Export Totals**
- **Pack Out Report**

CALIFORNIA APPLE COMMISSION 2004 - 2005

STATE	GALA	GRANNY SMITH	FUJI	PINK LADY	BRAEBURN	OTHER	TOTAL
ALABAMA	4733	20296	147				**25176**
ARIZONA	46215	22354	15932	15877	1899		**102277**
ARKANSAS				490			**490**
CALIFORNIA	481834	572472	202152	99255	15826	14180	**1385719**
COLORADO	10029	8384	2595	5893	1247	588	**28736**
CONNECTICUT	4141	6938	441	343			**11863**
DIST. OF COLUMBIA	2009	588					**2597**
FLORIDA	32807	67383	3739	539	49	147	**104664**
GEORGIA	15447	35147	4131	4765	70	385	**59945**
HAWAII	3961	773	7904				**12638**
IDAHO	1063	152					**1215**
ILLINOIS	19231	48388	4923	5151	284	984	**78961**
INDIANA	21948	13026	1647	1720	83	151	**38575**
IOWA	1911	12488	5767	1813			**21979**
KANSAS	829	1190	1630	660	300		**4609**
KENTUCKY	9343	7929	1001	2100	98		**20471**
LOUISIANA	3490	10362	877	343	147		**15219**
MAINE		21048		147			**21195**
MARYLAND	10490	29562	3981	5096			**49129**
MASSACHUSETTS	7385	50616	2464	2456	588	898	**64407**
MICHIGAN	42482	53382	11655	5660		735	**113914**
MINNESOTA	10443	37584	3163	1519	389	897	**53995**
MISSISSIPPI		6178	253	441			**6872**
MISSOURI	27428	30857	2915	3237	245		**64682**
MONTANA	2						**2**
NEBRASKA	399	959	900				**2258**
NEVADA	1764	2067	1684		98		**5613**
NEW JERSEY	12626	35047	8796	1647	379	682	**59177**
NEW MEXICO		245	56				**301**
NEW YORK	10546	140756	10677	10143	23		**172145**
NORTH CAROLINA	8702	1822	1890				**12414**
NORTH DAKOTA	98	49					**147**
OHIO	24331	31186	6976	4161			**66654**
OKLAHOMA	660	1676		490			**2826**
OREGON	3960	3403	274		226	3117	**10980**
PENNSYLVANIA	22595	50702	1975	1174		802	**77248**
SOUTH CAROLINA	2142	4475	770				**7387**
SOUTH DAKOKTA	147						**147**
TENNESSEE	17490	14881	1481	2892	480		**37224**
TEXAS	109934	123195	13452	41016	654	833	**289084**
UTAH	1759	2262	2414	833	120		**7388**
VERMONT	21					49	**70**
VIRGINIA	3450	2770	49				**6269**
WASHINGTON	14875	42601	9059	14481	613	281	**81910**
WISCONSIN	7421	6995	885	196			**15497**
TOTAL	**1,000,141**	**1,522,188**	**338,655**	**234,538**	**23,818**	**24,729**	**3,144,069**

CALIFORNIA APPLE COMMISSION 2005 - 2006

STATE	GALA	GRANNY SMITH	FUJI	PINK LADY	BRAEBURN	OTHER	TOTAL
ALABAMA	8590	12614		98			**21302**
ARIZONA	35616	46533	5976	6925	3224	966	**99240**
CALIFORNIA	345553	586557	233198	86394	10523	19017	**1281242**
COLORADO	12876	15412		2628	1720	685	**33321**
CONNECTICUT	5818	9423	73				**15314**
DIST. OF COLUMBIA		1029					**1029**
FLORIDA	19077	62217	13679	1456	27	367	**96823**
GEORGIA	11679	42381	5771	1253	182	413	**61679**
HAWAII	1849	2159	6992	98			**11098**
IDAHO	241	3366	98	349			**4054**
ILLINOIS	12446	36630	5370	4345	877	1794	**61462**
INDIANA	7627	27558	1147	3323	196	1872	**41723**
IOWA	980	13392	980	980	980		**17312**
KANSAS	3048	3587	774	1099	372		**8880**
KENTUCKY	3059	13237	3297	535		197	**20325**
LOUISIANA	3618	5136	1078				**9832**
MAINE		19860					**19860**
MARYLAND	15104	35433	4399	7694	244	196	**63070**
MASSACHUSETTS	9139	116721		1267			**127127**
MIAMI	88						**88**
MICHIGAN	20632	61084	14578	6246	343	294	**103177**
MINNESOTA	9486	42536	1609	1351	507	331	**55820**
MISSISSIPPI	4910	8428	2142				**15480**
MISSOURI	10864	24705	6809	2058	392		**44828**
NEBRASKA	751	1499					**2250**
NEVADA	2310	2573	1488	421	490		**7282**
NEW JERSEY	24084	43424	5293	6618	231	691	**80341**
NEW MEXICO	196	98					**294**
NEW YORK	10493	101993	9141	3670	98	86	**125481**
NORTH CAROLINA	5773	6646	4535	819	451		**18224**
OHIO	17958	28239	8797	2090	147	49	**57280**
OKLAHOMA	1313	441	343	735			**2832**
OREGON	4419	7434	58	84	794	5387	**18176**
PENNSYLVANIA	13036	35101	624	98	392	504	**49755**
SOUTH CAROLINA	4410	8491	833				**13734**
TENNESSEE	16744	32722	3875	5398	49		**58788**
TEXAS	75792	131056	22161	36854	1109	2193	**269165**
UTAH	3713	1946	1049	1139	98		**7945**
VERMONT	1232	2146	35		28	42	**3483**
VIRGINIA	5674	4518	882		1225		**12299**
WASHINGTON	23680	44760	2531	2166	1193	441	**74771**
WEST VIRGINIA		49					**49**
WISCONSIN	5534	11914	1211	3528	1027		**23214**
TOTAL	**759,412**	**1,655,048**	**370,826**	**191,719**	**26,919**	**35,525**	**3,039,449**

CALIFORNIA APPLE COMMISSION 2006 - 2007

STATE	GALA	GRANNY SMITH	FUJI	PINK LADY	BRAEBURN	OTHER	TOTAL
ALABAMA	2656	4399					**7055**
ARIZONA	30400	29025	5028	147	1899		**66499**
ARKANSAS		585					**585**
CALIFORNIA	204262	586417	200049	56273	6810	13478	**1067289**
COLORADO	9403	36244	3913	5946	1938	781	**58225**
CONNECTICUT	336	5425					**5761**
DIST. OF COLUMBIA		1071					**1071**
FLORIDA	26197	69204	10275			544	**106220**
GEORGIA	12266	36035	3730	2580		756	**55367**
HAWAII	777	320	2784	49			**3930**
IDAHO	98		49				**147**
ILLINOIS	10096	29889	2889	196	2413	855	**46338**
INDIANA	17419	33295	2286	1617	173	844	**55634**
IOWA	4935	15631	490	1515	3234	10	**25815**
KANSAS	1281	4333	2548	341	735		**9238**
KENTUCKY	11193	16981	126	686		162	**29148**
LOUISIANA	3267	2255	665				**6187**
MAINE	2646	20952		1182			**24780**
MARYLAND	7987	21705	2199	3276		238	**35405**
MASSACHUSETTS	10051	48224	5488	196			**63959**
MICHIGAN	30560	41796	12812	8174			**93342**
MINNESOTA	3475	27835				232	**31542**
MISSISSIPPI	1115	2963	1015				**5093**
MISSOURI	20077	151876	2827	6538			**181318**
NEBRASKA	880	1554	420				**2854**
NEVADA	271	3152	1691	147			**5261**
NEW HAMPSHIRE		21				98	**119**
NEW JERSEY	6124	22393	1029			215	**29761**
NEW MEXICO			740				**740**
NEW YORK	5586	82820	2731	2031			**93168**
NORTH CAROLINA	2622		3871				**6493**
OHIO	22764	60542	5932	5444		83	**94765**
OKLAHOMA	5966	2118					**8084**
OREGON	2513	4398		1735	49	245	**8940**
PENNSYLVANIA	6206	23398	6392		160	394	**36550**
RHODE ISLAND		196					**196**
SOUTH CAROLINA	360	343					**703**
TENNESSEE	6012	24801					**30813**
TEXAS	68366	161211	14463	27939	3645	1470	**277094**
UTAH	6978	6519		1326	294		**15117**
VIRGINIA	5529	5052	730				**11311**
WASHINGTON	37198	27844					**65042**
WEST VIRGINIA		98					**98**
WISCONSIN	4291	4459	147	511			**9408**
TOTAL	**592,163**	**1,617,379**	**297,319**	**127,849**	**21,350**	**20,405**	**2,676,465**

CALIFORNIA APPLE COMMISSION 2007 - 2008

STATE	GALA	GRANNY SMITH	FUJI	PINK LADY	BRAEBURN	OTHER	TOTAL
ALABAMA	7007	1877	320				**9204**
ARIZONA	34869	21659	8327	658		57	**65560**
ARKANSAS	2749	1552					**4301**
CALIFORNIA	164591	401910	211817	73568	13359	16357	**881602**
COLORADO	14522	18184	2796	2744	172	371	**38789**
CONNECTICUT		637				637	**1274**
DIST. OF COLUMBIA		196					**196**
FLORIDA	27818	11543	796	1139	245	683	**42224**
GEORGIA	11209	17193	3325			731	**32458**
HAWAII	1352	36	2094	419	14	181	**4096**
IDAHO	1380	518					**1898**
ILLINOIS	6389	22202	2411	3648	2450	2286	**39386**
INDIANA	23194	19032	370	392	444	1176	**44608**
IOWA		8701	3517	980	2576		**15774**
KANSAS	1959		98	3185			**5242**
KENTUCKY	7624	9313					**16937**
LOUISIANA	4312	3129					**7441**
MAINE	2111	23199	770				**26080**
MARYLAND	9861	13381	541	2100	637	280	**26800**
MASSACHUSETTS	10845	29823	147	2401			**43216**
MICHIGAN	20274	15431	5718	196		588	**42207**
MINNESOTA	3509	28185	21	441	2458	619	**35233**
MISSISSIPPI	3045	6026	245				**9316**
MISSOURI	30558	11485	3708	4984			**50735**
MONTANA	0	0	0	0	0	0	**0**
NEBRASKA	4015	2126	63		63		**6267**
NEVADA	2824	5802	1705		230		**10561**
NEW HAMPSHIRE	103	221				424	**748**
NEW JERSEY	3829	15642	2520	294		396	**22681**
NEW MEXICO	1323	3170	640				**5133**
NEW YORK	6096	59925	2675	2450	49	478	**71673**
NORTH CAROLINA	8894	4251	1095				**13145**
OHIO	28481	25165	4282	294		293	**58515**
OKLAHOMA	6035		2400				**8435**
OREGON	2569	629	372		97	963	**4630**
PENNSYLVANIA	8453	15585	476			227	**24741**
RHODE ISLAND	49	490					**539**
SOUTH CAROLINA	3221	670	140				**4031**
TENNESSEE	8584	16207		49			**24840**
TEXAS	61877	107510	12190	32238	1655	980	**216450**
UTAH	10760	4261	1215	147	137		**16520**
VERMONT	0	0	0	0	0	0	**0**
VIRGINIA	6371	3574	1365	539			**11849**
WASHINGTON	5414	6932			98	189	**12633**
WEST VIRGINIA	0	0	0	0	0	0	**0**
WISCONSIN	2909	4760		959			**8628**
WYOMING	4220	2640	570				**7430**
TOTAL	**565,205**	**944,772**	**278,729**	**133,825**	**24,684**	**27,916**	**1,974,026**

CALIFORNIA APPLE COMMISSION 2008 - 2009

STATE	GALA	GRANNY SMITH	FUJI	CRIPPS PINK	BRAEBURN	OTHER	TOTAL
ALABAMA	17805	10038	3914				**31757**
ALASKA	98						**98**
ARIZONA	24454	30298	4107	1078		24	**59961**
ARKANSAS	6475	525					**7000**
CALIFORNIA	274786	673536	177101	93594	4384	25446	**1248847**
COLORADO	12467	17015	3761	3111	844	1260	**38458**
CONNECTICUT	196	2707					**2903**
DIST. OF COLUMBIA	98						**98**
FLORIDA	47269	21400	1081	98	234	3263	**73345**
GEORGIA	15113	23352	4315		147	735	**43662**
HAWAII	1116	677	2709				**4502**
IDAHO	5261	539	294				**6094**
ILLINOIS	21029	34519	3986	343	98	2298	**62273**
INDIANA	15385	18390	2816	1260	84	1957	**39892**
IOWA	588	3094					**3682**
KANSAS	1793	1029	147	245			**3214**
KENTUCKY	11478	12793	1274	666		310	**26521**
LOUISIANA	5026	4782	875				**10683**
MAINE		13174					**13174**
MARYLAND	9307	44072	735	1323	196	49	**55682**
MASSACHUSETTS	13838	74234	1568	2030		247	**91917**
MICHIGAN	35521	67219	8872	9342			**120954**
MINNESOTA	7742	30086	787	1666	28	2464	**42773**
MISSISSIPPI	7868	4646	98				**12612**
MISSOURI	27449	16864	3066	774	98		**48251**
MONTANA		91				49	**140**
NEBRASKA	5605	3525					**9130**
NEVADA	49	3772	196				**4017**
NEW HAMPSHIRE	196	735			221	285	**1437**
NEW JERSEY	11738	46759	441		441	372	**59751**
NEW MEXICO	7450	2742			186		**10378**
NEW YORK	11631	84835	2033	2295	285	758	**101837**
NORTH CAROLINA	21744	8981	2905				**33630**
NORTH DAKOTA		49					**49**
OHIO	33557	34912	4914	6057	147	349	**79936**
OKLAHOMA	10081	3379	935				**14395**
OREGON	8598	9562	2170	735	294	4403	**25762**
PENNSYLVANIA	18972	32776	977	294	441	859	**54319**
SOUTH CAROLINA	4345	4896					**9241**
SOUTH DAKOTA	98						**98**
TENNESSEE	18900	21901		1022			**41823**
TEXAS	98687	130521	11938	27833	245	2759	**271983**
UTAH	14046	11734	3798	2205			**31783**
VIRGINIA	13701	10329	882	147			**25059**
WASHINGTON	20675	26060	2597			471	**49803**
WISCONSIN	11926	5619					**17545**
WYOMING	8355	3960					**12315**
TOTAL	**882,516**	**1,552,127**	**255,292**	**156,118**	**8,373**	**48,358**	**2,902,784**

CALIFORNIA APPLE COMMISSION 2009 - 2010

STATE	GALA	GRANNY SMITH	FUJI	CRIPPS PINK	BRAEBURN	OTHER	TOTAL
ALABAMA	22663						**22663**
ARIZONA	26552.6	19541	3420.2	2798		91	**52402.8**
ARKANSAS	13630	3885					**17515**
CALIFORNIA	149145.5	369232	102671.4	56641	9459.9	7272	**694421.8**
COLORADO	8166	4477	6486	1253	955	625	**21962**
CONNECTICUT	588	1813					**2401**
DIST. OF COLUMBIA	196	98					**294**
FLORIDA	41921.5	7412	4711		98	798	**54940.5**
GEORGIA	15769.2	6911	4354		490	196	**27720.2**
HAWAII	963	196	1470				**2629**
IDAHO							**0**
ILLINOIS	30488.3	13201	7799	392	294	1478	**53652.3**
INDIANA	32647	12166	5726	238	245	392	**51414**
IOWA		3318	141	980	14		**4453**
KANSAS	132.3		679	294			**1105.3**
KENTUCKY	12877	5831	98		147	175	**19128**
LOUISIANA	6530	2140	2625				**11295**
MAINE	4140	22842					**26982**
MARYLAND	2598	27267	3758	98	147	536	**34404**
MASSACHUSETTS	3773	38984	2914	3073	2082	21	**50847**
MICHIGAN	20237.2	27456	882	4265			**52840.2**
MINNESOTA	5537	33074	35	490	147	1055	**40338**
MISSISSIPPI	6480	769	49				**7298**
MISSOURI	24122	3360	3555	2591			**33628**
MONTANA	441	294	98		49		**882**
NEBRASKA	10755	2040					**12795**
NEVADA	9400	4428					**13828**
NEW HAMPSHIRE	196	949	147			226	**1518**
NEW JERSEY	9596.3	18128				484	**28208.3**
NEW MEXICO	10685	196	147	98	49		**11175**
NEW YORK	12789.3	61930	4221	2606	2576	327	**84449.3**
NORTH CAROLINA	12041	2212	2115			21	**16389**
NORTH DAKOTA	98						**98**
OHIO	31194	12076	2655	3670		439	**50034**
OKLAHOMA	16354	1505	2520				**20379**
OREGON	2298	5037	1666		98	189	**9288**
PENNSYLVANIA	21725.05	30759	4277.7		667.1	963	**58391.85**
SOUTH CAROLINA	8970	1054					**10024**
SOUTH DAKOTA							**0**
TENNESSEE	23015.4	8267.9	98				**31381.3**
TEXAS	90441.18	61265	7539	22239	245	1421	**183150.18**
UTAH	24394	6667	3724	224			**35009**
VIRGINIA	9983.5	4465	398.3				**14846.8**
WASHINGTON	14969	6605	5334			105	**27013**
WISCONSIN	9708	3820	2800	147	182		**16657**
WYOMING	15253	3504					**18757**
TOTAL	**763,463**	**839,175**	**189,114**	**102,097**	**17,945**	**16,814**	**1,928,608**

CALIFORNIA APPLE COMMISSION - UNITED STATES 2010 - 2011

STATE	GALA	GRANNY SMITH	FUJI	CRIPPS PINK	BRAEBURN	OTHER	TOTAL
ALABAMA	14342	49					**14391**
ARIZONA	59031	42189	714	490	1593	269	**104286**
ARKANSAS	3960	3700					**7660**
CALIFORNIA	336880.4	360229.7	258476.4	84676.7	16105.2	27485.53	**1083854**
COLORADO	10817.8	6159	2093	1909	49	1225	**22252.8**
CONNECTICUT		2940					**2940**
DIST. OF COLUMBIA	854	784	98				**1736**
FLORIDA	25780.6	13003.1	4368	240.1	128.1	499	**44018.9**
GEORGIA	20929.8	15512	4246	1078		927.1	**42692.9**
HAWAII	987	123	441				**1551**
ILLINOIS	40796.3	25316.8	4796			538.5	**71447.6**
INDIANA	16546	9054	4375		98	1939	**32012**
IOWA	2072	2058			49		**4179**
KANSAS	98	98		1073			**1269**
KENTUCKY	14323	1074	147	5880	514		**21938**
LOUISIANA	4234	5499	1995				**11728**
MAINE	1738	17983					**19721**
MARYLAND	3647	23335	1239	2177		1470	**31868**
MASSACHUSETTS	4879	56419	2205	5376	245		**69124**
MICHIGAN	5150	14247	6037	652	245		**26331**
MINNESOTA	9996.3	49460	245	2695	326	441	**63163.3**
MISSISSIPPI	6039						**6039**
MISSOURI	15068.5	10924.5	2660	1470	98		**30221**
MONTANA				49			**49**
NEBRASKA	4175						**4175**
NEVADA	18566	24762	49				**43377**
NEW HAMPSHIRE	441	147			147	288	**1023**
NEW JERSEY	7135	23917	985	273.7		1331	**33641.7**
NEW MEXICO	11296	2798	244		98		**14436**
NEW YORK	7020.15	68482.8	1905.15	1118	98		**78624.1**
NORTH CAROLINA	12746	6768	4011	50	529.2	1	**24105.2**
NORTH DAKOTA	98						**98**
OHIO	13440	5911	5295	5864		190	**30700**
OKLAHOMA	12915.2	8098	1934.2	196			**23143.4**
OREGON	7470	947	2176	486	87	273	**11439**
PENNSYLVANIA	24328.2	27605	4684	1078	539	378	**58612.2**
SOUTH CAROLINA	6650	7806					**14456**
TENNESSEE	13569.3	6692.2	1862	1862			**23985.5**
TEXAS	102382.7	74606.2	10105.5	24338	1835.4	1883	**215150.8**
UTAH	22768	147	116	490	28		**23549**
VIRGINIA	6860	4508		637			**12005**
WASHINGTON	9543	13650	4620			196	**28009**
WEST VIRGINIA				3			**3**
WISCONSIN	9943	5528	1610	539			**17620**
WYOMING	8590	5637	2240				**16467**
TOTAL	**898,106**	**948,167**	**335,972**	**144,701**	**22,812**	**39,334**	**2,389,092**

CALIFORNIA APPLE COMMISSION - UNITED STATES 2011 - 2012

STATE	GALA	GRANNY SMITH	FUJI	CRIPPS PINK	BRAEBURN	OTHER	TOTAL
ALABAMA	14602.2	14319		147			**29068.2**
ARIZONA	33583.3	27018	3405	5160		1653	**70819.3**
ARKANSAS	9425						**9425**
CALIFORNIA	187132.7	251077.4	102186.3	48385.15	2600.5	60198	**651580.05**
COLORADO	18294.3	15684.9	3009	1596	303	1429	**40316.2**
CONNECTICUT	3388	1568	98				**5054**
DIST. OF COLUMBIA	196	196				686	**1078**
FLORIDA	35384.2	30768.4	2588		21	3174	**71935.6**
GEORGIA	31182.5	17718	7505	2450		3058	**61913.5**
HAWAII	294	98	343				**735**
IDAHO	133	539					**672**
ILLINOIS	41511.1	35830.9	4893.1	3920	245	5609	**92009.1**
INDIANA	34460.6	31970	3103		210	2925	**72668.6**
IOWA	483.1	5497	32		234		**6246.1**
KANSAS	2604.6	4440	198.7	588		1675	**9506.3**
KENTUCKY	14240	23990	882		147	1397	**40656**
LOUISIANA	13133	5045	3220				**21398**
MAINE	1631	11870					**13501**
MARYLAND	6451	17761.3	21655	7028		3155	**56050.3**
MASSACHUSETTS	4949	37752.4	4655	6909	156	8272	**62693.4**
MICHIGAN	26632.6	21455.3	7670	196	420	4953	**61326.9**
MINNESOTA	11598.3	54720.5	49	2429	1742.3	19808	**90347.1**
MISSISSIPPI	3705	3045					**6750**
MISSOURI	27841.7	16293.3	5754	1637		3466	**54992**
MONTANA	245	1077					**1322**
NEBRASKA	7605	7163.1		168			**14936.1**
NEVADA	7319	7323	245			1134	**16021**
NEW HAMPSHIRE	350	420			21	290	**1081**
NEW JERSEY	6344	18777	196		14	812	**26143**
NEW MEXICO	11473	5948	49				**17470**
NEW YORK	8182.2	36120.1	2128	3393		5186	**55009.3**
NORTH CAROLINA	8000	24677.2	2974	416.8	63	273	**36404**
NORTH DAKOTA		28		40		147	**215**
OHIO	42361.3	24357.1	7017	539	98	1428	**75800.4**
OKLAHOMA	13444.7	12475.2	1533		145	49	**27646.9**
OREGON	2685.7	4004.9	196			962	**7848.6**
PENNSYLVANIA	19164.7	33233	2856	7894	258	3615	**67020.7**
RHODE ISLAND		147					**147**
SOUTH CAROLINA	1160	10472				294	**11926**
TENNESSEE	15619.7	12703.5		1746		2058	**32127.2**
TEXAS	91224.8	93039.95	6795	19445	441	7071	**218016.75**
UTAH	27451.7	13053	4420	735		98	**45757.7**
VERMONT	196	49					**245**
VIRGINIA	8295	11546	686			1134	**21661**
WASHINGTON	18581	28204	6569		49	7093	**60496**
WISCONSIN	8934	10636	665	196	33	637	**21101**
WYOMING	18420	5235	1820				**25475**
TOTAL	**839,913**	**989,347**	**209,396**	**115,018**	**7,201**	**153,739**	**2,314,612.30**

CALIFORNIA APPLE COMMISSION - UNITED STATES 2012 - 2013

STATE	GALA	GRANNY SMITH	FUJI	CRIPPS PINK	BRAEBURN	OTHER	TOTAL
ALABAMA	7357	9864	186				**17407**
ARIZONA	17341	16655	4374	1294	21		**39685**
ARKANSAS	3998						**3998**
CALIFORNIA	219877	297090	94785	45606	5645	15727	**678730**
COLORADO	12799	8610	2401	266	125	1674	**25875**
CONNECTICUT	343	539					**882**
FLORIDA	32641	16582	4880	29		98	**54230**
GEORGIA	19698	16398	8218	2940	147		**47401**
HAWAII	1076	1027	1244				**3347**
IDAHO	490						**490**
ILLINOIS	27676	14968	1581	9124	411	1238	**54998**
INDIANA	10106	6154	3357		98	671	**20386**
IOWA	952	3846	98	294	1019		**6209**
KANSAS	2500	819		294			**3613**
KENTUCKY	7181	24046	260		196	98	**31781**
LOUISIANA	2413	1664	4164				**8241**
MAINE	854	6514					**7368**
MARYLAND	3528	12831	2037	1390	14	532	**20332**
MASSACHUSETTS	13181	20379	3087	1420	392	21	**38480**
MICHIGAN	20278	21915	18758		21		**60972**
MINNESOTA	2010	43745	693	581	695	2049	**49773**
MISSISSIPPI	6829						**6829**
MISSOURI	23265	19175	3049				**45489**
MONTANA	196			182			**378**
NEBRASKA	1708						**1708**
NEVADA	3450	10680	296				**14426**
NEW HAMPSHIRE	147	245	52			1459	**1903**
NEW JERSEY	603	10569	472			1299	**12943**
NEW MEXICO	3899	147					**4046**
NEW YORK	10400	28939	1205	1716	56	42	**42358**
NORTH CAROLINA	2399	4811	1313				**8523**
NORTH DAKOTA		209					**209**
OHIO	22938	10808	2874	1743	49	980	**39392**
OKLAHOMA	9288	49	455				**9792**
OREGON	3309	2891		686		137	**7023**
PENNSYLVANIA	14849	27839	1889	4471	35	1310	**50393**
SOUTH CAROLINA	2764	3136					**5900**
TENNESSEE	9751	7925		490			**18166**
TEXAS	81150	84894	9104	19239	978	2551	**197916**
UTAH	11847	777	399	1540	35		**14598**
VERMONT	49						**49**
VIRGINIA	1894	2296	377				**4567**
WASHINGTON	9238	14858	134	1070	147		**25447**
WISCONSIN	7845	294	287	91	444		**8961**
WYOMING	5178		175				**5353**
TOTAL	**639,296**	**754,189**	**172,204**	**94,466**	**10,528**	**29,886**	**1,700,568**

CALIFORNIA APPLE COMMISSION - UNITED STATES 2013 - 2014

STATE	GALA	GRANNY SMITH	FUJI	CRIPPS PINK	BRAEBURN	OTHER	TOTAL
ALABAMA	17,359.61	940.80		98.00	294.00		**18,692.41**
ARIZONA	21,303.86	10,779.00	1,618.00	4,035.00	427.00		**38,162.86**
ARKANSAS	11,709.75						**11,709.75**
CALIFORNIA	223,144.99	426,553.70	173,135.10	102,500.80	8,041.10	36,557.00	**969,932.69**
COLORADO	3,396.75	1,979.00	359.00	70.00	196.00	1,481.00	**7,481.75**
CONNECTICUT	851.38						**851.38**
DIST. OF COLUMBIA	931.00						**931.00**
FLORIDA	31,727.50	6,234.80	3,909.00	70.00	583.00	469.00	**42,993.30**
GEORGIA	12,703.50	9,871.10	3,587.00		441.00	49.00	**26,651.60**
HAWAII	405.85	98.00	1,785.00				**2,288.85**
ILLINOIS	41,011.76	5,532.10	3,968.10	2,695.00		442.00	**53,648.96**
INDIANA	16,402.02	18,087.00	1,632.00	533.00		728.00	**37,382.02**
IOWA	2,403.45	3,925.00	1,715.00	903.00	1,078.00		**10,024.45**
KANSAS				430.00			**430.00**
KENTUCKY	10,043.78	5,902.00	245.00	80.00	490.00	523.00	**17,283.78**
LOUISIANA	4,822.00	83.00	1,785.00	15.00			**6,705.00**
MAINE	1,950.00	1,666.00					**3,616.00**
MARYLAND	1,798.30	196.00	128.00	441.00	14.00	642.00	**3,219.30**
MASSACHUSETTS	5,612.60	14,423.00	2,372.00	2,691.00	343.00	1,116.00	**26,557.60**
MICHIGAN	8,770.53	8,987.00	5,375.00		224.00		**23,356.53**
MINNESOTA	1,920.00	23,794.00	441.00	828.00	1,597.20	405.00	**28,985.20**
MISSISSIPPI	7,152.31						**7,152.31**
MISSOURI	26,910.19	3,136.00	2,190.00	490.00			**32,726.19**
NEVADA	9,787.11	13,275.00	49.00				**23,111.11**
NEW HAMPSHIRE	77.00	294.00	98.00		371.00	147.00	**987.00**
NEW JERSEY	1,225.00	7,109.00	296.00	889.00	752.00	1,246.00	**11,517.00**
NEW MEXICO	13,368.16	93.10	142.10		28.00		**13,631.36**
NEW YORK	5,804.50	18,127.00	1,050.00	2,564.00	1,225.00		**28,770.50**
NORTH CAROLINA	9,202.00	3,418.00	3,129.00		21.00	70.00	**15,840.00**
OHIO	18,018.92	5,054.00	6,986.00	2,366.00		852.00	**33,276.92**
OKLAHOMA	20,949.73						**20,949.73**
OREGON	147.00	1,591.50			49.00	314.00	**2,101.50**
PENNSYLVANIA	13,292.00	21,603.00	4,659.20	885.40	337.00	1,420.00	**42,196.60**
SOUTH CAROLINA	3,345.00	352.80		49.00			**3,746.80**
TENNESSEE	5,690.05	5,647.00		2,532.80			**13,869.85**
TEXAS	99,327.74	126,276.00	3,950.00	16,169.00	920.00	1,463.00	**248,105.74**
UTAH	16,700.13	2,614.00		1,195.00			**20,509.13**
VIRGINIA	1,847.00	2,221.20			784.00		**4,852.20**
WASHINGTON	10,019.80	49,734.00				98.00	**59,851.80**
WISCONSIN	2,430.00	28.00	2,249.00		49.00		**4,756.00**
WYOMING	2,976.00						**2,976.00**
TOTAL	**686,538.27**	**799,625.10**	**226,852.50**	**142,530.00**	**18,264.30**	**48,022.00**	**1,921,832.17**

CALIFORNIA'S TOP 5 STATES

	2000 - 2001	
1	California	1,282,349
2	New York	239,647
3	Texas	193,518
4	Arizona	98,490
5	Florida	94,463

	2001 - 2002	
1	California	1,146,587
2	New York	473,316
3	Texas	212,378
4	Massachusetts	105,896
5	Florida	96,877

	2002 - 2003	
1	California	1,348,951
2	Texas	279,028
3	Massachusetts	126,021
4	New York	191,624
5	Illinois	141,671

1	2003 - 2004	
2	California	1,409,491
3	Texas	328,190
4	New York	212,095
5	Florida	153,483
	Illinois	130,305

	2004 - 2005	
1	California	1,385,719
2	Texas	289,084
3	New York	172,145
4	Michigan	113,914
5	Florida	104,664

	2005 - 2006	
1	California	1,281,242
2	Texas	269,165
3	Massachusetts	127,127
4	New York	125,481
5	Michigan	103,177

	2006 - 2007	
1	California	1,067,289
2	Texas	277,094
3	Missouri	181,318
4	Florida	106,220
5	Ohio	94,765

	2007 - 2008	
1	California	881,602
2	Texas	216,450
3	New York	71,673
4	Arizona	65,570
5	Ohio	58,515

	2008 - 2009	
1	California	1,071,112
2	Texas	253,561
3	Michigan	109,280
4	New York	87,951
5	Massachusetts	75,794

	2009 - 2010	
1	California	694,422
2	Texas	183,150
3	New York	84,449
4	Pennsylvania	58,392
5	Florida	54,940

	2010 - 2011	
1	California	1,083,854
2	Texas	215,150
3	Arizona	104,286
4	New York	78,624
5	Illinois	71,447

	2011 - 2012	
1	California	651,580
2	Texas	218,016
3	Illinois	92,009
4	Minnesota	90,347
5	Ohio	75,800

	2012 - 2013	
1	California	678,730
2	Texas	197,916
3	Michigan	60,972
4	Illinois	54,998
5	Florida	54,230

	2013 - 2014	
1	California	969,932
2	Texas	248,105
3	Washington	59,851
4	Illinois	53,648
5	Florida	42,993

EXPORT TOTALS FOR 2006 - 2007

COUNTRY	GALA	GRANNY SMITH	FUJI	PINK LADY	BRAEBURN	OTHER	TOTAL
CANADA	119,581	182,319		147		345	**302,392**
CHINA		980					**980**
COLOMBIA		8,793					**8,793**
COSTA RICA		2,251		980			**3,231**
ECUADOR		6,412					**6,412**
EL SALVADOR	840	2,058					**2,898**
HONDURAS		413					**413**
INDIA		4,038					**4,038**
INDONESIA		3,500					**3,500**
MALAYSIA		73,409	9			217	**73,635**
MEXICO	21,244	34,352	2,229				**57,825**
NICARAGUA		380					**380**
PANAMA	686	3,990		980			**5,656**
PERU		1,960					**1,960**
PHILIPPINES		2,938					**2,938**
PUERTO RICO	24	221					**245**
SINGAPORE	840	33,844					**34,684**
SRI LANKA		10,216					**10,216**
TAIWAN	3,267	8,826	95,505				**107,598**
THAILAND	2,520	3,185					**5,705**
UNITED KINGDOM				57,531			**57,531**
VENEZUELA		1,568					**1,568**
TOTAL	**149,002**	**385,653**	**97,743**	**59,638**	**0**	**562**	**692,598**

EXPORT TOTALS FOR 2007 - 2008

COUNTRY	GALA	GRANNY SMITH	FUJI	PINK LADY	BRAEBURN	OTHER	TOTAL
CANADA	121,382	115,132	199	343	312	804	**238,172**
COLOMBIA		1,911					**1,911**
ECUADOR		1,848					**1,848**
GUATEMALA	533	846					**1,379**
HONG KONG		6,420					**6,420**
INDIA		5,823	980				**6,803**
INDONESIA		1,800					**1,800**
JAMAICA	490						**490**
KUWAIT		1,911					**1,911**
MALAYSIA		56,378	1,555			84	**58,017**
MEXICO	16,737	1,494					**18,231**
PANAMA	2,131	3,969					**6,100**
PERU		980					**980**
PUERTO RICO	49						**49**
SAUDI ARABIA	4,742						**4,742**
SINGAPORE		21,367	524				**21,891**
SRI LANKA		1,911					**1,911**
TAIWAN			30,786				**30,786**
THAILAND	1,462	1,154	756				**3,372**
UNITED KINGDOM				31,298			**31,298**
TOTAL	**147,526**	**222,944**	**34,800**	**31,641**	**312**	**888**	**438,111**

EXPORT TOTALS FOR SEASON 2008 - 2009

COUNTRY	GALA	GRANNY SMITH	FUJI	CRIPPS PINK	BRAEBURN	OTHER	TOTAL
CANADA	93,120	130,021	8,858	147		906	**233,052**
COLOMBIA		931					**931**
COSTA RICA		441					**441**
ECUADOR		4,200					**4,200**
HONG KONG		1,928					**1,928**
INDIA		3,920					**3,920**
INDONESIA		11,260					**11,260**
JAMAICA	392						**392**
MALAYSIA		129,263	196				**129,459**
MEXICO	58,409	38,038	3,773				**100,220**
NEW ZEALAND		5,128					**5,128**
PANAMA	994	6,603	784				**8,381**
SINGAPORE		44,532					**44,532**
SRI LANKA		6,878					**6,878**
TAHITI	30						**30**
TAIWAN		1,927	68,341				**70,268**
THAILAND		2,860					**2,860**
UNITED ARAB EMIRATES		3,528					**3,528**
UNITED KINGDOM				16,443			**16,443**
TOTAL	**152,945**	**391,458**	**81,952**	**16,590**		**906**	**643,851**

EXPORT TOTALS FOR SEASON 2009 - 2010

COUNTRY	GALA	GRANNY SMITH	FUJI	CRIPPS PINK	BRAEBURN	OTHER	TOTAL
CANADA	73,849	54,643	1,127	392		119	**130,130**
COLOMBIA		1,960					**1,960**
COSTA RICA	900	98					**998**
ECUADOR		1,680					**1,680**
EL SALVADOR	2,700						**2,700**
INDIA		1,078					**1,078**
INDONESIA		13,173					**13,173**
JAMAICA	45						**45**
MALAYSIA		38,509					**38,509**
MEXICO	13,197	2,058					**15,255**
PANAMA	490	1,078	267				**1,835**
PERU		2,254					**2,254**
PHILLIPPINES		1,917					**1,917**
SAUDI ARABIA		2,156					**2,156**
SINGAPORE	840	17,234					**18,074**
TAIWAN	5,840	6,589	59,033				**71,462**
THAILAND	900	4,760					**5,660**
UNITED ARAB EMIRATES		14,065					**14,065**
UNITED KINGDOM	1,820						**1,820**
VIETNAM		980					**980**
TOTAL	**100,581**	**164,232**	**60,427**	**392**		**119**	**325,751**

EXPORT TOTALS 2010 - 2011

COUNTRY	GALA	GRANNY SMITH	FUJI	CRIPPS PINK	BRAEBURN	OTHER	TOTAL
CANADA	51,241	63,779	98	1,617		147	116,882
COLOMBIA		980					980
ECUADOR		294					294
HONG KONG		3,038					3,038
INDIA		245					245
INDONESIA		14,592					14,592
MALAYSIA		13,643					13,643
MEXICO	17,339	17,297					34,636
NEW ZEALAND		980					980
PERU		2,900					2,900
PHILLIPPINES		3,871					3,871
SINGAPORE		4,580					4,580
TAIWAN	2,664	2,590	31,700				36,954
THAILAND		3,890					3,890
VIETNAM		4,900					4,900
TOTAL	71,244	137,579	31,798	1,617		147	242,385

EXPORT TOTALS 2011 - 2012

COUNTRY	GALA	GRANNY SMITH	FUJI	CRIPPS PINK	BRAEBURN	OTHER	TOTAL
CANADA	161,846	49,674	2,450	2,143		16,675	232,788
COLOMBIA		980					980
ECUADOR		5,965					5,965
HONG KONG		965					965
INDONESIA		1,940					1,940
MALAYSIA		30,818					30,818
MEXICO	9,968	8,799		2,058			20,825
PANAMA		7791					7,791
PERU		2,940					2,940
PHILLIPPINES		2,910					2,910
SRI LANKA		5,880					5,880
TAIWAN			15,629				15,629
THAILAND		5,769					5,769
TOTAL	171,814	124,431	18,079	4,201	0	16,675	335,200

EXPORT TOTALS 2012 - 2013

COUNTRY	GALA	GRANNY SMITH	FUJI	CRIPPS PINK	BRAEBURN	OTHER	TOTAL
CANADA	147,268	57,066	9,635	980	147	931	216,027
COLOMBIA		2,875					2,875
COSTA RICA	911						911
EL SALVADOR	931						931
HONG KONG		1,029					1,029
INDONESIA		2,940					2,940
MALAYSIA		31,713					31,713
MEXICO	13,425	26,278					39,703
PANAMA		1,617					1,617
PERU		3,087					3,087
PHILLIPPINES		2,903					2,903
PUERTO RICO		42					42
SINGAPORE		5,419					5,419
SRI LANKA		900					900
TAIWAN		5,152	31,384				36,536
THAILAND		9,775					9,775
VIETNAM		980					980
TOTAL	162,535	151,776	41,019	980	147	931	357,388

EXPORT TOTALS 2013 - 2014

COUNTRY	GALA	GRANNY SMITH	FUJI	BRAEBURN	OTHER	TOTAL
CANADA	74,805	43,226	13,388	196	490	132,105
ECUADOR		2,696				2,696
FRENCH POLYNESIA	294					294
INDONESIA		980				980
MALAYSIA		46,509				46,509
MEXICO	199	30,985				31,184
PERU		931				931
PHILLIPPINES		6,860				6,860
PUERTO RICO	49					49
SINGAPORE		4,662				4,662
SRI LANKA		11,680				11,680
TAIWAN	19	4,786	5,504			10,309
THAILAND		7,825				7,825
UNITED ARAB EMIRATES		4,655				4,655
VIETNAM		3,900				3,900
TOTAL	75,366	169,695	18,892	196	490	264,639

2003 - 2014 End of Season Pack Out Report

VARIETY	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014
FUJI	814,870 808,514	897,665 583,122	469,146 451,294	375,371 375,371	295,886 295,886	337,244 337,244	249,541 249,541	367,770.3 367,770.3	227,475 227,475	213,223 213,223	245,745
GALA	1,205,601 1,186,842	1,151,528 1,126,900	942,987 798,008	755,617 755,617	714,879 714,879	1,035,461 1,035,461	864,044 864,044	969,350.2 969,350.2	1,011,727 1,011,727	801,831 801,831	761,904
GRANNY SMITH	2,144,406 2,100,288	1,696,470 1,597,885	1,947,108 1,501,192	2,029,851 2,029,851	1,244,291 1,244,291	1,943,585 1,943,585	805,345 805,345	1,085,746 1,085,746	1,113,778 1,113,778	905,965 905,965	969,320
CRIPPS PINK	313,490 300,430	300,418 269,393	214,894 214,894	191,764 191,764	165,477 165,477	172,708 172,708	102,489 102,489	146,317.5 146,317.5	119,219 119,219	95,446 95,446	142,530
BRAEBURN	9,911 9,911	13,570 13,570	26,504 13,360	23,160 23,160	24,831 24,831	8,373 8,373	17,945 17,945	22,297.9 22,297.9	7,201 7,201	10,675 10,675	18,460
60ARKANSAS BLACK								6,796.4 6,796.4			
GOLDEN DELICIOUS			3 2				739 739	1,452 1,452			
GRAVESTEIN				4 4				8 8			
HONEYCRISP								9,010.6 9,010.6			8,998
JONAGOLD					492 492						
LADY APPLE								293.13 293.13			
PIPPIN								274 274			
RED DELICIOUS			908 908	400 400	780 780		678 678	512 512	639 639	671 671	2,015
SPITZENBERG								180 180			
SUNDOWNER	20,923 20,923	8,870 8,870	12,954 12,954	2,244 2,244	1,177 1,177						
OTHER			22,134 22,134	20,110 20,110	26,355 26,355	49,264 49,264	15,516 15,516	21,469 21,469	169,775 169,775	30,146 30,146	37,499
Total Packed	**4,509,201**	**4,068,521**	**3,636,638**	**3,398,521**	**2,474,168**	**3,546,635**	**2,056,297**	**2,631,477**	**2,649,814**	**2,057,957**	**2,186,471**
Total Shipped	**4,426,908**	**3,599,740**	**3,014,746**	**3,398,521**	**2,474,168**	**3,546,635**	**2,056,297**	**2,631,477**	**2,649,814**	**2,057,957**	**2,186,471**