Summary 2013 Annual Project Reports

Complete reports are available at:
www.tomatonet.org/2013

2013 SUMMARY ANNUAL RESEARCH REPORT

INTRODUCTION

Welcome, this report marks the 45th year of continuous crop research sponsored by California processing tomato growers. This report presents summaries of research funded by the contributing growers of the California Tomato Research Institute, Inc.

For 2013 the full report will be only available in electronic form at www.tomatonet.org/2013 This summary report will be available at industry meetings, events and also at our website.

It is our goal to provide useful timely information, geared to assisting growers in both daily production decisions and long term crop improvement. The Institute Board of Directors continues to support a broad range of projects, addressing both current problems and long range concerns.

INDEX OF RESEARCH PROJECT REPORTS BY CATEGORY

Agronomic Projects

Breeding, Genetics & Variety Development Projects

Disease Management Projects

Weed Management Projects

Project Title:

Irrigation and Salinity Management for High Yielding Processing Tomato Systems

Project Leaders: Tom Turini, Dan Munk, Jon Wroble and Devon Rodriguez
University of California Cooperative Extension

Steve Grattan
University of California, Davis, Department of Land Air and Water Resources

Abstract:
Influence of irrigation reductions on drip-irrigated processing tomato yield and quality were assessed in Fresno County from 2010 to 2012. The irrigation regimes compared in the study were the following: *a*) the grower treatment, which is ET + 10%; *b*) same as *a* until 60 days before projected harvest, then, 80% ET to 30 days before the projected harvest and 60% for the remainder of the season; *c*) same as *b*, but 60% ET imposed from 60 to 30 days before projected harvest and 40% ET for the remainder of the season. The irrigation water used throughout the study was high quality surface water. Drip tape was not changed during the study and the beds were only tilled to a depth of 4 to 6 inches. Each bed within the study received the same irrigation treatment during this study. Yields as determined by mechanical harvest of the trial areas were high over all three years and unaffected by the irrigation treatments, with the exception of a 5.26 ton/acre reduction in yield in the plots with the most severe irrigation reduction in 2012. Hand sorts and laboratory analysis of sub-samples showed that treatments had no significant influence on fruit quality. Substantial quantities of sub-surface moisture were mined during all seasons, which contributed to the overall good condition of these crops. When applied water + rainfall were considered, there was a significant negative correlation between water quantities and salinity accumulation. Because the field was irrigated with high quality district water, the additional drip-applied water may have aided in salinity management. However, while there was a numerical decrease in soil salinity, variability was very high so no significant reduction in electrical conductivity or chloride was observed. Furthermore, the position of increased salinity levels within the soil profile was often associated with the center of the bed at depths of 13 to 24 inches, which could present challenges for the crop. While a drip-applied leaching fraction with high quality water may aid in salinity management, based on this work, it is not advisable to use as the only tactic for addressing this issue.

Project Title:

Design and Investigation of Water Use Efficient and 'Climate Smart' Risk Management Cropping Systems for Tomato in the Central Valley

Project Leader: Jeff Mitchell
Department of Plant Sciences, University of California, Davis
Telephone (559) 303-9689 Fax (559) 646-6593
jpmitchell@ucdavis.edu

Summary of 2013 Findings:

Since 1999, we have evaluated the amount of cover crop biomass that may be produced ahead of tomatoes in a study field in Five Points, CA. During this period, with supplemental irrigations applied in 2000 and 2013 amounting to about 8 inches, over 19 tons of organic matter (OM) (dry weight basis) and 7 tons of carbon (C) have been added to the soil in the cover crop

These data point to a number of observations including 1) the variability of cover crop production with variable SJV winter rainfall, and 2) the ability to provide significant amounts of OM and C to the soil during this intercrop period.

To extend work on changes in soil properties that may result from these carbon inputs, in 2013, we evaluated a range of soil attributes using the USDA NRCS Soil Quality Test Kit. Data from these assays are provided in Table 1. Abbreviations are the same as in Table 1 with STNO being standard tillage without cover crop and CTNO indicating conservation tillage without cover crop.

	Aggregate stability (%)	Water holding capacity (%)	Infiltration (time for 400 ml)	Infiltration (time for additional 400 ml)
STNO	43	35.4	2:04	8:17
STCC	57.8	35.9	0:51	6:22
CTNO	48.5	34.6	1:08	5.09
CTCC	58.2	32.9	0:17	1:40

Table 2. **Soil property assessments under standard tillage no cover crop (STNO), standard tillage with cover crop (STCC), conservation tillage with no cover crop (CTNO), and conservation tillage with a cover crop (CTCC)**

These data indicate increased aggregate due to cover cropping and conservation tillage, no difference in terms of water holding capacity using the technique that we developed in 2013, and faster infiltration again with cover crops and also with conservation tillage.

Project Title:

Evaluation of Irrigation Practices on Water Use, Soil Salinity, and Tomato Productivity in the Delta

Project Leaders: Brenna Aegerter and Michelle Leinfelder-Miles
Farm Advisors
UCCE, San Joaquin County
2101 E. Earhart Ave. Ste. 200, Stockton, CA 95206
Phone 209-953-6100 FAX 209-953-6128
Email: bjaegerter@ucanr.edu and mmleinfeldermiles@ucanr.edu

Objective and Justification:
With this study, we are evaluating the impact of conversion to drip irrigation on water use, soil salinity, tomato yields, and fruit quality in the Delta. Results from this study will give growers knowledge on whether drip irrigation improves tomato yield and/or quality in the unique Delta growing environment, which is challenged by salinity.

Results and Discussion:
Pit sampling and soil testing. To date, we have processed 125 out of 355 soil samples. A significant amount of time was spent getting our lab system working correctly and making sure our tests results were accurate. This included running a set of 30 samples both at our UCCE lab and at the UC Davis Analytical Lab. Now that we have a system established and working efficiently, we expect to be able to finish testing the 230 remaining soil samples by the end of the calendar year. Figure 1 shows the results of the furrow and drip field pits prior to planting as an example of the type of data we will have once all the soil samples are processed. We will be able to compare the spring and fall spatial distribution of soil salinity across the bed and down to 3 feet in the drip-irrigated field.

Evapotranspiration and deficit irrigation. Consumptive water use (stored water used plus irrigation water applied) was very close to full ET for both treatments (Table 2). Therefore, the irrigation programs neither leached salts with drainage of excess irrigation water, nor resulted in a severe deficit for the plant. Our deficit irrigation cutback was not that much more severe than the grower's cutback at the end of the season, and amounted to 0.45 inches less, or 2.2% less. The fact that the stored soil moisture on October 2nd was the same for both the grower's irrigation program and the experimental program indicates that we could have implemented our cutbacks earlier in the season.

Yield and fruit quality. Machine harvested yields were high (just over 70 tons in the trial area) and were similar between the two irrigation strategies. Fruit quality was also similar between treatments (Table 3).

Project Title:

Effect of Mycorrhizal Inoculants and Plant Flavonoid Inducers on Processing Tomatoes

Principle Investigator: Kate Scow
Department of Land Air and Water Resources, UC Davis
3236 Plant and Environmental Sciences Building
One Shields Avenue
Davis, CA 95616

Cooperators:
Gene Miyao, Farm Advisor Vegetable Crops, UC Cooperative Yolo County
Emma Torbert, Assistant Specialist, Agricultural Sustainability Institute
Megan McCaghey, Graduate Student, Agricultural Sustainability Institute

Abstract or Summary Results:
Soil amendments have the potential to increase soil quality, increase beneficial soil organisms and reduce pathogenic soil organisms. However, the soil amendments in this experiment (compost, Regalia and MycoApply) did not significantly affect processing tomato yields, mycorrhizal colonization, or soil properties such as organic matter, pH, CEC or salt concentrations. The chicken manure compost treatment did increase soil concentrations of phosphorus, potassium and sulfur and decreased the overall severity of disease, as compared to treatments without compost. The total cost of the amendments (including material, labor and equipment to apply) was $489/acre. Of that total cost, $411/acre is due to the compost application alone. Long-term increases of yields and sustained lower disease incidence levels would be needed to justify the cost of applying the amendments.

Objectives:
Overall: To study the effect of plant flavonoid inducers (Regalia), soil amendments (compost)
and mycorrhizal inoculants (MycoApply) on commercial-scale processing tomatoes

Specific:
1) Conduct field trials testing the effectiveness of microbial soil amendments in a grower's processing tomato field
2) Measure effect of soil amendments, alone and in combination, on
- processing tomato yields
- plant health
- soil nutrient content
- mycorrhizal populations

3) Communicate results in field days, workshops and conferences on the effectiveness of microbial soil amendments

Project Title:
UCCE Statewide Processing Tomato Variety Evaluation Trials, 2013

Project Leader: Brenna Aegerter, Farm Advisor
UCCE San Joaquin County
2101 E. Earhart Ave., Ste 200
Stockton, CA 95206
209-953-6114
bjaegerter@ucanr.edu

Cooperating UC Personnel: Diane Barrett, Food Science & Technology CE Specialist, UC Davis

Tim Hartz, Vegetable Crops CE Specialist, UC Davis
Michelle Le Strange, Farm Advisor, Tulare & Kings Counties
Scott Stoddard, Farm Advisor, Merced & Madera Counties
Tom Turini, Farm Advisor, Fresno County
Mark Lundy, Farm Advisor, Colusa, Sutter & Yuba Counties

Summary:
University of California Cooperative Extension farm advisors, in cooperation with commercial growers and CTRI, conducted five mid-maturity variety evaluation trials in 2013. Seed companies submitted 13 replicated lines and 18 observational entries for the mid-maturity/full-season trial.

Among varieties in the replicated trials, HM 1892, H 1175, H 5608 and N 6407 were highest yielding, while H 1161, AB 0311, N 6402, N 6407 and SUN 6366 were highest in soluble solids. There were few yield differences in the observational variety trials, while soluble solids were highest from HMX 2898, BQ 311, H1285, BQ 296 and UG 16609. Variety yield varied by trial, highlighting the importance of looking at results from the individual trials to gauge variety performance under different conditions.

Objectives:
The major objective of our project is to evaluate pre-commercial and early commercial release processing tomato varieties for fruit yield, soluble solids, color, and pH in replicated field trials conducted at multiple locations statewide. The data are combined from multiple trials to evaluate variety adaptability under a wide range of growing conditions. These tests are designed and conducted with input from seed companies, processors, and other allied industry members and are intended to generate third-party information on varieties to assist in decision-making.

Project Title:
C. M. Rick Tomato Genetics Resource Center

Project Leader: Roger T. Chetelat
Department of Plant Sciences
University of California
Davis, CA 95616

Summary Project Report:

Acquisitions

The TGRC expanded its collection of genetic stocks and wild species accessions through donations from external researchers and by rescuing inactive collections from seed storage. We acquired 182 new accessions of cultivated tomato in 2013. The new stocks include 148 recombinant inbred lines (RILs) developed by Dr. Majid Foolad at Penn State Univ. from a cross between cv. NC EBR-1 x *S. pimpinellifolium* LA2093. The RILs are also being sequenced to provide high density marker information for mapping and breeding applications. This resource is expected to be useful for studying the genetic factors underlying economic traits such as yield, fruit size, fruit quality, and other traits important to breeders. We also acquired 15 mutant stocks with altered trichome biochemistry from Dr. Rob Last at Michigan State Univ. The mutant phenotypes include increased or decreased expression of several classes of phytochemicals related to plant defense against insects and wounding. In addition, 18 nearly isogenic lines (NILs) of developmental mutants with hormone deficiencies and/or altered physiological responses were acquired from Dr. Lazaro Peres from the Univ. de Sao Paulo. These NILs were developed by backcrossing each mutant into the genetic background of 'Micro-Tom', a compact patio variety popular for experimental research purposes. In addition, we regenerated several previously inactive wild species accessions which had never been grown by the TGRC. Obsolete or redundant accessions were dropped. The current total of number of active accessions is 3,848.

Maintenance and Evaluation

A total of 1,213 cultures were grown for various purposes, of which 555 were for seed increase (96 of which were of wild species) and 353 for germination tests. Progeny tests were performed on 82 stocks of segregating mutants (e.g. male steriles, homozygous lethals, etc) or various lines with unexpected phenotypes. Tests for the presence of transgenes (GMOs) were performed on 18 stocks, all of which were negative. Other stocks were grown to confirm wild species introgressions, or for research on interspecific reproductive barriers. Newly regenerated seed lots were split, with one sample stored at 5° C to use for filling seed requests, the other stored in sealed pouches at -18° C to better maintain long term seed viability. As allowed by harvests, backup seed samples were also submitted to the USDA Natl. Center for Genetic Resources Preservation in Colorado, and to the Svalbard Global Seed Vault in Norway.

Distribution and Utilization

A total of 4,718 seed samples representing 1,675 unique accessions were distributed in response to 304 requests from 227 colleagues in 22 countries; over 33 purely

informational requests were also answered. The overall utilization rate (i.e. number of samples distributed relative to the number of active accessions) exceeds 125%, showing that demand for our stocks remains high and that many accessions are requested at least once each year. Information provided by recipients indicates our stocks are being used to support a wide variety of research, breeding, and educational projects, many of which are relevant to tomato production. Our annual literature search again uncovered a large number of publications mentioning use of our stocks (see bibliography at http://tgrc.ucdavis.edu/reports.aspx).

Documentation

Our website (http://tgrc.ucdavis.edu) was updated in various ways to add features and address security issues. Security updates were made to our geographic mapping tools that allow plotting of wild species accessions using the GoogleMap software. Web pages related to seed requests were modified to enable charging for express shipping options and phytosanitary certificates. We revised our web pages with horticultural recommendations for growing the wild species, and added an illustrated tutorial on emasculating and pollinating tomato flowers. Descriptive data on new accessions were added and records on existing accessions were updated as needed. Our database was modified in various ways to improve internal record keeping related to seed requests, plant pedigrees, and seed lots. A revised list of wild species stocks was published in the Tomato Genetics Coop. Report (TGC).

Research

With funding from the National Science Foundation, the TGRC continued research on the mechanisms of interspecific reproductive barriers that restrict crosses between cultivated tomato and its wild relatives. We published a paper on the role of a pollen factor, *ui6.1,* in self-incompatibility. We also continued research on natural variation for pollen compatibility genes in self-compatible biotypes and species, and their role in transitions from outcrossing to inbreeding modes of reproduction. With support from the USDA-NIFA, we are developing a set of breeding lines representing the genome of *S. sitiens*, a wild tomato relative known for its tolerance to drought and salinity, but which has not been utilized in the past due to strong crossing barriers. The goal of this research is to develop a set of introgression lines – prebred stocks containing defined chromosome segments from the donor genome – that will provide the first breeder friendly germplasm resources for this wild species.

Note: For the complete project report, please visit http://tgrc.ucdavis.edu/reports.aspx.

Project Title:
Fruit Yields with Less Water: Beneficial Genes from Wild Tomato

Project Leader: Dr. Dina St. Clair
University of California-Davis, Department of Plant Sciences
One Shields Ave., Davis, CA 95616
Tel. (530) 752-1740; dastclair@ucdavis.edu

Co-investigator: Erin Arms
Graduate Student Researcher, Ph.D. candidate in Genetics
University of California-Davis, Department of Plant Sciences

Summary:
We are using "mRNA sequencing analysis" (mRNA-seq analysis) to identify genes from *S. habrochaites* involved in resistance to water stress. We conducted a water stress experiment with two of our breeding lines to induce expression of genes involved in water stress responses. Root samples from multiple plants of both lines were harvested and RNA extracted from the roots. Currently, our root RNA samples are in queue for mRNA-seq library preparation by technical staff at the UC-Davis Genome Center, followed by subsequent DNA sequencing at the Center. The project timeline was delayed due to unanticipated problems with obtaining quality RNA from roots and wait times for services provided by technical staff and specialized equipment at the UC-Davis Genome Center DNA Technology Core.

Objective:
Our project goal is to identify genes from chromosome 9 of wild tomato (*S. habrochaites*) that confer resistance to water stress and contribute to the maintenance of fruit yields under restricted irrigation.

Introduction:
Wild tomato (*S. habrochaites*) is highly resistant to water stress. Previously, we genetically mapped this resistance to chromosome 9, and determined that resistance is controlled by a root-to-shoot signal that causes leaf stomata to close, allowing plants to avoid wilting under water stress. We used marker-assisted selection to create a set of breeding lines containing different portions of this chromosome 9 region from *S. habrochaites*.
During summer 2012 and 2013, we conducted replicated field trials at UC-Davis with 18 of these tomato breeding lines under two drip irrigation treatments: full water, equivalent to the evapotranspiration rate (ETo) for tomato; and severely restricted water, 1/3 of ETo for tomato. We measured numerous plant traits, including fruit yields, fruit size and plant weight (biomass). We determined that breeding lines containing specific portions of the *S. habrochaites* chromosome 9 region had the ability to resist water stress and maintain fruit yields under limited water. Identification of the beneficial genes from chromosome 9 of *S. habrochaites* would provide useful and very specific targets for marker-assisted breeding of water-stress tolerance in processing tomato cultivars.

Project Title:

Development and Application of a Degree-Day Model and Risk Index to Predict Development of Thrips and *Tomato Spotted Wilt Virus* (TSWV) and Implement an IPM Strategy in California Processing Tomato Fields

Principal Investigator: Robert L. Gilbertson
Plant Pathologist, Department of Plant Pathology, UC Davis

Cooperating Personnel: Ozgur Batuman, Project Scientist, UC Davis
Li-Fang Chen, Postdoctoral Researcher, UC Davis
Michelle LeStrange, Farm Adviser, Kings County
Tom Turini, Farm Adviser, Fresno County
Scott Stoddard, Farm Adviser, Merced County
Gene Miyao, Farm Adviser, Yolo County
Brenna Aegerter, Farm Advisor, San Joaquin County
Neil McRoberts, Epidemiologist, UC Davis
Diane E. Ullman, Entomologist, UC Davis

Summary:

The goal of this project is the development and implementation of a predictive thrips phenology (degree-day) model and *Tomato spotted wilt virus* (TSWV) risk index (TRI) and to focus our ongoing monitoring efforts in northern counties (Solano, Yolo, Colusa, Sacramento and Sutter) and San Joaquin County (SJC). The long-term goal is to provide accurate and real-time information to growers about the population dynamics of thrips and development of TSWV infection to facilitate effective disease management with the integrated pest management (IPM) strategy that has been developed as part of this project.

In 2013, monitoring of tomato fields in northern counties (fifth year), and in San Joaquin County (first year) revealed similar thrips population dynamics, with a build-up of thrips populations beginning in early-April, a rapid population increase in early-May and moderately high populations through the summer. TSWV was first detected in a monitored tomato field on 11 April in the Brentwood area in SJC and not until 1 May in a field on the Yolo/Colusa county line area. TSWV was eventually detected in all monitored fields, but overall incidences were low (<1-20%). However, high incidences (up to 80%) were found in parts of two fields (one in Colusa and another in Sacramento/SJC) by early June.

Winter and spring weed surveys revealed very low levels of TSWV infection (~2% of all weeds tested). A notable exception was rough-seeded buttercup (*Ranunculus muricatus*)

in SJC and northern counties where this weed was identified as a potentially important reservoir of TSWV. Large numbers of buttercup weeds showed virus disease symptoms and high rates (85%) of TSWV infection were detected. TSWV-infected buttercups were detected in 9/17 walnut orchards surveyed, and this may explain grower observations of high TSWV incidences in tomato fields near walnuts.

Results of our laboratory experiments on the role of the soil-emerging adult thrips as an inoculum source for early season tomatoes revealed that thrips can stay dormant in soil for at least 7 weeks and that some emerging adults retained the virus and were able to infect plants. These results strongly suggest that adult thrips emerging from soil can be an inoculum source of TSWV. During the 2013 growing season, the web site for the thrips phenology (degree-day) model was made available for growers, and was regularly updated to provide thrips population projections for each area. This model accurately predicted the timing of adult thrips generations (>80% accuracy) in monitored areas. Thus, we believe that this model can be used as a reliable predictor of when thrips populations begin to increase in the spring and when it is best to apply thrips management strategies (e.g., early-mid-April in the northern counties and SJC in 2013). The prototype TSWV risk index (TRI) calculator was also made available on the web as well as on Smartphone, tablet and computer friendly interfaces. Growers submitted required field information interactively to the TRI calculator and received a prompt response from us with the TRI value for their field (low, moderate and high risk) and brief recommendations on how to prevent TSWV outbreaks. The TRI was moderate for most monitored fields in 2013. However, a number of low and high risk fields were identified, and the TSWV incidences in these fields were accurately predicted by the TRI. Thus, we believe that the IPM strategy for thrips and TSWV can be highly effective at reducing disease incidence, particularly if followed regionally. Key aspects include proper timing of thrips management strategies and identifying high risk fields where intensive IPM practices should be implemented. We now hope to put more efforts into encouraging the use and uptake of the grower-friendly thrips degree-day model and risk index, and to further publicize the IPM strategy for regional thrips and TSWV management.

Project Title:

Movement of Fusarium Oxysporum Via Equipment

Project Leaders:
Gene Miyao, UC Cooperative Extension
70 Cottonwood Street, Woodland, CA 95695
(530) 666-8732 emmiyao@ucdavis.edu

Mike Davis, CE Specialist
Dept. Plant Pathology, UC Davis
1 Shields Ave, Davis, CA 95616

Results:
Nearly 20% of the tomato plants were infected with Fusarium wilt by the 3rd year of cropping after the introduction of the pathogen to the soil. The fungus established readily and thereafter infection level progressively increased.

Objectives:
Evaluate establishment and movement of *Fusarium oxysporum* in causing Fusarium wilt from diseased tomato tissue introduced into non-infested soil. Movement of infected tomato plant debris is most probable with harvest equipment moving the pathogen within a field as well as between fields.

Results:
A total of 264 plants were lab confirmed to be diseased with Fusarium wilt from the 2013 test plot.

Discussion:
Our field study indicated that Fusarium wilt can readily establish in a new soil environment, infect the following season and multiple quickly (Table 1).
The results suggest equipment, especially tomato harvesters and vine diverters that routinely trap and carry plant debris, should be cleaned before transporting between fields to reduce the spread of this and other pathogens.

Table 1. Evaluation of spread of Fusarium wilt from Nov 2010 field introduction, UC Davis

year	Visually infected plants* (#)	infected (%)
2010	-	-
2011	12	1%
2012	34	2%
2013	287	19%

* with lab confirmation

Project Title:
Influence of Drip Irrigation on Tomato Root Health

Project Leader: Mike Davis w/ Johan Leveau, Gene Miyao
Cooperative Extension Specialist, Department of Plant Pathology
One Shields Ave, University of California, Davis, CA 95616
Phone 530-752-0303, email rmdavis@ucdavis.edu

Objectives:

1. Evaluate the interaction of drip irrigation, composted chicken manure, fungicides, and fertilizers on root health, root and soil microbiota, and tomato fruit yield and quality in field experiments.
2. Study the effect of chicken manure on soil microbial activity, plant nutrition, and management of soilborne pathogens of tomato in controlled greenhouse trials.
3. Determine the efficacy of *Collimonas*, a parasite of fungi, on suppression of soilborne diseases.
4. Develop diagnostics tools for *Fusarium oxysporum* f. sp. *radicis-lycopersici*, the cause of Fusarium crown and root rot of tomato.

Abstract:
Experiments were conducted in four commercial tomato fields in Yolo and Solano counties. All fields used buried drip irrigation. In one location, the effects of preplant-incorporation of composted poultry manure, different fertilizer regimes, and several biologically-based materials delivered through the drip tape were examined. Single manure applications at 5 and 10 tons per acre significantly increased yields (64 and 71 tons per acre, respectively) relative to the nontreated control (57 tons). The control was the grower's standard practice with normal fertilizer rates and practices. Supplemental fertilizers also significantly increased yields. No treatment reduced the incidence of Verticillium wilt, the predominate disease in the field. In two other locations, no treatment, including poultry manure, supplemental fertilizers, biologicals, and a fungicide, influenced fruit yields or disease incidence. The placement of poultry manure (either buried or incorporated after a surface application) with and without gypsum was evaluated in the forth location. No treatment influenced fruit yield or quality. DNA was extracted for determination of soil microbial community structure. In previous experiments, no significant differences in soil bacterial or fungal community composition were detected between soil samples collected from poultry manure treatments and other treatments. Overall, our data suggest that soil microbiota in the tomato fields under study are unaffected by disease management tools such as fungicides, biocontrol agents, and composted manures. Greenhouse trials that evaluated the effects of the bacterium *Collimonas* and Serenade Soil on Fusarium wilt of tomato were completed. Neither Serenade Soil nor *Collimonas* by itself reduced the effects of Fusarium wilt; together, however, there was a beneficial synergistic response. This experiment was repeated three times in various iterations with the same results. At least three genotypes of *Fusarium oxysporum* f. sp. *radicis-lycopersici*, the cause of Fusarium crown and root rot of tomato, were identified in California from submitted samples. All have been reported elsewhere in the world. We are continuing to refine our methodology for a quick and accurate DNA-based assay to distinguish Forl from Fol and other fungi.

Project Title:

Screening for Resistance to Bacterial Speck and Monitoring California *Pseudomonas syringae* Strains

Project Leader: Gitta Coaker
Associate Professor
Department of Plant Pathology
University of California Davis
Phone: 530-752-6541
E-mail: glcoaker@ucdavis.edu

Collaborator: Gene Miyao
Farm Advisor, Vegetable Crops
E-mail: emmiyao@ucdavis.edu

Introduction:

Bacterial speck of tomato, caused by *Pseudomonas syringae* pv. *tomato*, can significantly impact plant health and lead to decreased yields, fruit symptoms that can pose problems for whole-peel processors, as well as plant death in seedlings. Traditionally *P. syringae* pv. *tomato* has been controlled by a combination of copper sprays and genetic resistance conferred by the tomato genes Pto and Prf (Pedley and Martin 2003). Pto and Prf are effective in mediating resistance against Race 0 strains. However, Race 1 strains were first detected in California in 2000 (Arredondo and Davis 2000). In 2005, 2010 and 2011, outbreaks of bacterial speck occurred (Kunkeaw, Tan et al. 2010). The PI (G. Coaker) has been monitoring field strains of *P. syringae* over the last five years and has found that almost all field strains are exclusively Race 1 and possess moderate to high levels of copper resistance (Kunkeaw, Tan et al. 2010).

Results for Objective 1: Identification of tomato genotypes exhibiting resistance to current *P. syringae* strains.

Identification of Solanum habrochaites resistant material

We have made good progress on completing this objective. In addition to the susceptible cultivar Bonnie Best and the known resistant accession *S. peruvianum*, we screened three other wild tomato accessions for resistance against race 1 *P. syringae*: *S. habrochaites, S. pimpinellifolium,* and *S. pennellii* (Figure 1). An additional source of resistance from the wild tomato species *S. habrochaites* was identified (Figure 1). Importantly, this particular accession of *S. habrochaites* already has a set of recombinant inbred lines developed (Monforte and Tanksley 2000). Recombinant inbred lines (RILs) are made by crossing two inbred parents followed by many generations of selfing to produce a population with individuals that are homozygous mosaics of each parent's genome. In this RIL population, there are 93 lines, each containing a different segment of *S. habrochaites* DNA with the remaining genome belonging to cultivated tomato *S. esculentum* cv ES6203 (Monforte and Tanksley 2000). Taken together, the RIL population covers 85% of the *S. habrochaites* genome. The genetic location of *S. habrochaites* DNA is mapped in each line, which can be used to rapidly narrow down regions conferring resistance and provide markers for future breeding efforts.

Project Title:

Management of Root-Knot Nematodes with Novel Nematicides

Project Leaders: J. Ole Becker
Department of Nematology
1463 Boyce Hall, UC Riverside, CA 92521
(951) 827 2185, obecker@ucr.edu

Antoon Ploeg
Department of Nematology, UC Riverside, CA

Joe Nunez
UCCE Bakersfield, CA

Summary:

Field trials were conducted at the UC South Coast Research and Extension Center (SCREC) and at Shafter to evaluate the efficacy of several novel soil nematicides and two biological control products on root-knot nematode population development, tomato root health and yield. The products were applied at different rates and/or times according to the manufacturer's recommendation. Vydate and an untreated control served as standard checks. Of the products tested, the two nematicides showed excellent efficacy against root-knot nematodes. At SCREC MCW-2 significantly reduced early and late-season root galling and increased tomato yields by 26% over the non-treated check. This confirms our result from last year's trials. Another development product (DP) that was noted for its promising activity at the Shafter location in 2012, showed again excellent efficacy. It significantly reduced early and late-season root galling and at SCREC increased tomato yields over the non-treated control by up to 36%. The Shafter trial suffered from major curly top incidence but still confirmed the nematicidal efficacy of MCW-2 and DP based on disease ratings at harvest.

Project Title:

Genome Sequencing of the Bacterial Canker Pathogen, *Clavibacter Michiganensis* Subsp. *Michiganensis*, to Develop Robust Detection and Disease Control Strategies

Project Leader: Gitta Coaker
Associate Professor
Department of Plant Pathology
University of California Davis
Phone: 530-752-6541
E-mail: glcoaker@ucdavis.edu

Co-PI: Robert Gilbertson

Introduction:

Bacterial canker of tomato, caused by *Clavibacter michiganensis* subsp. *michiganensis* (*Cmm*), can cause significant losses in greenhouse and field tomato production under favorable environmental conditions (Eichenlaub and Gartemann 2011). Although seed disinfestation with HCl is a highly effective disease control strategy, bacterial canker can still develop if seed treatment is not complete or if other sources of inoculum are present. Detection of the disease in the field is now commonly performed with immunostrips, but these are not very sensitive and are prone to false positives due to the presence of non-pathogenic bacteria that are closely related to *Cmm*. PCR with *Cmm* primers is a more sensitive method, but it is technically challenging and the currently available primers may only detect a subset of *Cmm* strains present in the field (Eichenlaub and Gartemann 2011). Development of robust PCR detection method for *Cmm* would enable rapid detection of contaminated seed or seedlings before planting or transplanting, respectively. Furthermore, there are no existing chemical or genetic disease control methods for this pathogen. The goals of the funded research are to sequence the genomes of 5 *Clavibacter* strains in order to develop a robust PCR detection strategy and test the efficacy of novel chemical control strategies based off genome sequencing information. This is the first year of a proposed three year grant. There are three objectives in the proposal:

Objective 1: Sequence and assemble four strains of *Clavibacter michiganensis* subsp. *michiganensis* as well as one saprophytic *Clavibacter* isolate.
Objective 2: Mine the genome sequence data to develop robust PCR detection strategies for *Clavibacter michiganensis* subsp. *michiganensis.*
Objective 3: Test the efficiency of novel chemical control strategies based on information from genome sequencing.

Project Title:

A Genomics Approach to Unravel the Molecular Pathogenesis of Powdery Mildew on Tomato

Project leader: Ioannis Stergiopoulos
Assistant Professor
Department of Plant Pathology, University of California Davis
578 Hutchison Hall, One Shields Avenue, Davis, CA 95616-8751
Office: 530-400-9802, fax: 530-752-1199
email: istergiopoulos@ucdavis.edu

Cooperating Personnel: Mike Davis
Plant Pathology Specialist, Department of Plant Pathology
University of California, Davis, CA 95616
Office: 530-752-0303, fax: 530-752-5674
email: rmdavis@ucdavis.edu

Summary:
In tomato, powdery mildew is caused by the species *Leveillula taurica* and *Oidium neolycopersici*, which are primarily associated with the disease in field and greenhouse grown tomatoes, respectively. The aim of this study is to obtain the genome sequence and transcriptome of *L. taurica,* in order to gain a deeper understanding of the molecular mechanisms that govern development and pathogenicity of this fungus on its host. Most efforts during the first year of this study have so far have focused on overcoming a number of technical challenges regarding generating monospore cultures of *L. taurica* in the lab and propagating these cultures on a living plant host in order to obtain enough fungal material (i.e. conidiospores) that can be used to isolate high quality DNA and RNA. In contrast to primary believes, we also report on the presence of mixed infections by *L. taurica* and *O. neolycopersici* in open tomato fields around Davis and elsewhere in California. This is quite an important observation that can have serious consequences for the control of the disease in the fields, and thus one that we currently try to confirm on a molecular level as well.

Project Title:

Field Bindweed Management in Early and Late Planted Processing Tomatoes

Project Leader

Lynn M. Sosnoskie, Assistant Project Scientist
259 D Robbins Hall, University of California - Davis
Department of Plant Sciences, MS-4
One Shields Avenue
Davis, CA 95616
(229) 326-2676
lmsosnoskie@ucdavis.edu

CO-PIs:

Bradley D. Hanson, Extension Weed Specialist
Davis, CA 95616
(530) 752-8115
bhanson@ucdavis.edu

W. Thomas Lanini, Extension Weed Ecologist
(530) 752-4476
wtlanini@ucdavis.edu

Summary

Field bindweed (*Convovulous arvensis*) is a deep-rooted perennial that is difficult to control once it has become established. Bindweed should be managed for up to eight weeks following tomato transplanting in order to reduce interspecific competition and maximize crop yields. Bindweed control is highly dependent on weed development and the timing of herbicide applications; it is assumed that herbicide performance could vary throughout the production season. Field studies were conducted during the summer of 2013 to evaluate the efficacy of currently registered herbicides for field bindweed management in early and late planted processing tomato**.** Results show that bindweed cover and density were significantly reduced, relative to the controls, when using an herbicide program that included trifluralin (incorporated to a depth of 2-3 inches prior to planting) and either rimusulfron or carfentrazone (applied post-emergence or shielded, respectively). The use of metolachlor and sulfentrazone (pre-plant incorporated) or rimsulfuron (pre-emergence), in combination with trifluralin, also helped to reduce field bindweed density in late planted tomatoes. Pre-plant applications of glyphosate to emerged bindweed (late planted tomatoes) reduced weed cover by more than half in herbicide-treated plots, supporting a common IPM recommendation that all growers should strive to plant into clean fields. Although crop injury was observed in response to herbicide treatments, phytotoxicity was minimal and transient. Crop yields were statistically higher in all herbicide treatments, relative to the checks.

Project Title:

Evaluating Herbicide Carryover in Sub-surface Drip-irrigated Tomatoes

Principle Investigator: Kurt Hembree
Weed Management Farm Advisor
UC Cooperative Extension, Fresno County
550 E. Shaw Ave.,Suite 210-B, Fresno, CA 93710
Phone: (559) 241-7520
kjhembree@ucanr.edu

Co-Investigators: Thomas Turini
Vegetable Crops Farm Advisor
UC Cooperative Extension, Fresno County
550 E. Shaw Ave.,Suite 210-B, Fresno, CA 93710
Phone: (559) 241-7529
taturini@ucanr.edu

Summary:
Beginning in 2009, stunted tomato plants with substantial root reduction were observed where labeled rates of dinitroaniline herbicides were routinely used in commercial processing tomato fields in western Fresno County, where semi-permanent beds and sub-surface drip irrigation are now a common practice. The field patterns and plant symptoms observed were consistent with injury by dinitroaniline herbicides. To address this issue, we began a three-year field study at the UC West Side Research & Extension Center (WSREC) in Five Points, CA to evaluate dinitroanilin herbicide carryover and impact on tomato health and production in a three-year tomato rotation using permanent raised beds with sub-surface drip irrigation. Pre-plant use of Treflan (trifluralin) and Prowl H2O (pendimethalin) were evaluated under sub-surface drip and sub-surface drip plus overhead sprinkler irrigation. Initially, shoot and root dry weights were lower where sprinkler irrigation was used, but differences could not be detected later and plots yielded fruit similarly. Stand was also reduced slightly where sprinklers were used, compared to drip-only plots. Neither of the herbicide treatments used influenced plant dry weight, stand, or yield. Soil analyses for trifluralin and pendimethalin indicated that there was no downward movement of either herbicide through the soil profile, even where sprinkler irrigation was used during crop establishment. While trifluralin was not detectable in the soil by harvest, about 10% of the pendimethalin remained in the upper three-inches of the soil. This indicates possible carryover into next year's planting cycle, with the potential of causing crop injury similar to what we had been observing in commercial fields. There was a 50% infection rate of Curly top virus across the trial area, resulting in yields of about 45 ton/acre. This resulted in reduced yields across the trial for the area.

Project Title:
Field Bindweed Management in Drip Irrigated Processing Tomatoes

Project Leader: Scott Stoddard
Farm Advisor
Merced & Madera Counties
2145 Wardrobe Ave.
Merced, CA 95340
209-385-7403; cell: 209-777-SOIL
csstoddard@ucdavis.edu

Summary:
Field studies were conducted at WSREC near Five Points to evaluate the efficacy of registered herbicide combinations in controlling field bindweed (*Convolvulsus arvensis*) in drip irrigated processing tomatoes. The herbicides tested suppressed field bindweed growth, but none of the herbicides provided complete control. Treflan was the most effective preemergence treatment for suppressing established field bindweed, and post emergence treatments with Matrix or Shark improved control in most instances. Slight crop phytotoxicity was noted at WSREC for Prowl, Treflan, and Zeus preplant incorporated; however, symptoms of herbicide damage were not apparent by the end of the season. Other broadleaf and grassy weeds, especially lambsquarters, became very problematic by the end of the season, and when combined with irrigation difficulties, prevented yields from being estimated.