2014 Annual Project Report

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2014 Summary

Research Project Reports

Projects are categorized by project type and listed, in order of starting date

Use the bookmarks feature to easily navigate to each project.

Agronomic/Water/Nutrient Mgmt.		**$33,880**
Evaluation of Precision Commercial Tomato Production Systems - continuation	Jeff Mitchell	$5,000
Evaluation of irrigation practices on water use, soil salinity, and tomato productivity in the Delta	Brenna Aegerter	$6,880
Developing a sampling protocol to estimate pre-plant nitrate availability in subsurface drip irrigated tomato	Martin Burger	$6,000
Investigation of Sustaining Tomato Plant Health and Yield with Composted Manure	Gene Miyao	$16,000
Breeding/Genetics/Varieties		**$37,590**
Tomato Genetics Resource Center	Roger Chetelat	$15,000
Fruit yields with less water: beneficial genes from wild tomato	Dina St. Clair	$12,990
Marker Genotyping of Chromosome 9 From Water-stress Resistant Wild Tomato to Generate Breeding Lines	Dina St. Clair	$9,600
Insect & Invertibrate Mgmt.		**$28,127**
Evaluation of Tactics for Improvement of Stink Bug Control	Thomas Turini	$28,127
Pathogen and Nematode Mgmt.		**$270,185**
Tomato Spotted Wilt Virus (TSWV) Analysis and Management	Robert L. Gilbertson	$31,000
Evaluation of Fungicides, & Others for the Control of Southern Blight	Joe Nuñez	$7,000
Evaluation of New Nematicides Against Root-knot Nematodes in Processing Tomato Production	J. Ole Becker	$35,862
Effect of Cover Crops, Compost and Gypsum Soil Additions on Processing Tomatoes	Kate Scow	$39,318
Genome sequencing of the bacterial canker pathogen, to develop robust detection and disease control strategies.	Gitta Coaker	$46,259
Detection of Aazole and Strobilurin Fungicide Resistant Strains of Tomato Powdery Mildew in California	Ioannis Stergiopoulos	$17,003
Curly Top Research: Objectives Relevant to Tomatoes	Robert L. Gilbertson	$42,000
Evaluation of Chemical Control of Bacterial Speck	Gene Miyao	$7,500
Synergy–based Biocontrol of Fusarium Wilt of Tomato	Johan Leveau	$39,993
Evaluation of Root Knot Nematode Control with Resistant Wheat and Various Cover Crops	Gene Miyao	$4,250
Weed Control and Mgmt.		**$50,016**
Field Bindweed Management in Processing Tomatoes	Lynn Sosnoskie	$15,836
Evaluating Herbicide Carryover in Sub-surface Drip Irrigated Tomatoes	Kurt Hembree	$34,180
		$419,798

Project Title: **Evaluation of Precision Commercial Tomato Production Systems for Increased Competitiveness, Resource Use Efficiency and Soil Quality Using Study Sites in Five Points and Los Banos**

Project Leader:

Jeff Mitchell *Department of Plant Sciences, University of California, Davis, 9240 S. Riverbend Avenue, Parlier, CA 93648, Telephone (559) 646-6565, Fax (559) 646-6593, Mobile (559) 303-9689, mitchell@uckac.edu*

Project Collaborators:

(15 - See Full Version)

Initial Conclusions:

Some of the cover crop treatment soils show highest species richness, while some of the no cover crop soils show least richness.

The standard till no cover crop treatments and the conservation tillage no cover crop treatment at the 0 – 5 cm show similar trends in community composition and also cluster together in beta diversity analysis.

The sequencing results are consistent with other data from Five Points and show that:

- Cover crops exert a strong influence on microbial community composition as well as soil properties, and
- The standard tillage no cover crop treatment is distinct from the other three treatments.

Over the fifteen years that we have been evaluating the use of reduced tillage and cover crops in Five Points, a total of 25.6 t ha^{-1} of aboveground cover crop biomass was produced with a total precipitation of 209 cm and 20 cm of supplemental irrigation. Cover crop biomass varied from 39 kg ha^{-1} in the low precipitation period of the 2006 – 2007 winter to 9,346 kg ha^{-1} in the first winter (2000 – 2001). We also determined changes in soil water storage under three cover crop mixtures compared to fallowed plots during two (2013 and 2014) winter periods in a separate study to investigate tradeoffs associated with water use by cover crops in this region. Soil water storage in the sampled depth for the fallow and each of the cover crop mixtures was compared each year from January to March. Soil water storage increased during this period for the fallow system by 4.8 cm in 2013 and 0.43 cm in 2014, but in the cover crop mixture plots, there was no additional water storage. Instead, water was used by the cover crops resulting in a negative water balance of an average of 0.47 cm in 2013 and 0.26 cm in 2014 for the cover crop mixes. Thus, compared to the fallow system, cover crops depleted 5.3 cm and 0.67 cm more water in from the 0 – 90 cm profile in 2013 and 2014, respectively.

While the greater water depletion of cover crops may present concerns associated with integrating cover crops into cash cropping systems in water-limiting environments, these greater water depletions can be recovered or even be turned into water surpluses by implementing cover crops in crop rotations along with conservation tillage practices that maintain crop residues on the soil surface thereby reducing evaporative losses. This study illustrates the critical value of long-term systems research in providing clear, robust implications of crop management options that may not be apparent in shorter duration investigations due to not being able to account for the impacts of inter-annual variability of climatic conditions on research findings.

Our data suggest that while vigorous growth of winter cover crops in this area of the Central Valley may not be possible in all years due to low and erratic precipitation patterns, in most years there may be benefits of cover cropping in terms of providing greater crop cover, residue, and photosynthetic energy capture. We are now working with two SJV tomato farmers to further evaluate tradeoffs between the use of cover crops and soil water depletions under local conditions.

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
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Objective:

We are evaluating how conversion to drip irrigation affects water use, soil salinity, tomato yields, and fruit quality in the Delta.

Abstract:

To document the distribution of salinity in the soil profile, intensive soil sampling was conducted down to a 40" depth at two field sites on Roberts Island in the Delta; one irrigated by alternate furrows, the other by sub-surface drip irrigation. In the drip field, the soil was sampled from two areas; one irrigated with the grower's program, the other with a more severe irrigation cutback beginning 7 weeks before harvest. Overall, these two fields did not have salinity problems; the average root zone salinity remained below the thresholds of 2.5 dS/m for electrical conductivity (EC_e) and 875 ppm for chloride. In the drip field, despite the fact that water was not applied in excess of crop evapotranspiration (ET), the upper part of the root zone was kept fairly clean of salts. However, leaching occurred more horizontally rather than vertically, likely due to very fine organic matter at the third foot depth which impeded downward leaching. Salinity levels were somewhat higher in the rows with greater irrigation cutbacks (2.3" less water applied), but only by 0.2 dS/m. The average salinity increased only slightly from year one to two, in part attributable to the good quality irrigation water (EC_w of 0.4 for the 2013 season and 0.6 for 2014). Had the quality of the water been poorer, it would be recommended to increase applied water to levels exceeding ET to leach salts out of the root zone. For the furrow-irrigated field, average EC_e values increased by 0.5 dS/m towards the bottom end of the field, but did not change over the season towards the top end. This indicates better leaching at the top of the field due to a longer opportunity time for water to infiltrate. Irrigating over a longer run time may provide for better leaching at the bottom end of the field. However, longer run times will also increase runoff from the field and could result in problems with standing water on clay soils. At the fall sampling time point, the bottom of the field had many samples exceeding the 2.5 dS/m salinity threshold, but most of these samples were from the lower depths where there were fewer roots. Irrigating weekly with alternate furrows and good quality water appears to have been effective at preventing a damaging buildup of salinity at the center of the bed.

Project Title:
Developing a sampling protocol to estimate pre-plant nitrate availability in subsurface drip irrigated tomato systems

Principal Investigators:

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Collaborators:

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Tom Turini, Cooperative Extension Fresno County, UC ANR. E-mail: taturini@ucanr.edu

Objectives:

1) Develop a soil sampling protocol to adequately estimate pre-plant nitrate (NO_3^-) availability;

2) Assess the effects of SDI and winter precipitation on the spatial distribution of NO_3^-, potassium (K) and phosphorous (P) availability in fields of varied precipitation and evapotranspiration regimes;

3) Assess the apparent N use efficiency, defined as the ratio of crop nitrogen (N) uptake to N availability (pre-plant NO_3^- + N fertilizer applications).

Summary
Systematic soil sampling was carried out in 16 commercial subsurface drip-irrigated tomato production fields in Yolo, San Joaquin, and Fresno Counties to assess the distribution of nitrate, available phosphate, and exchangeable potassium in the top 20 inches of soil at pre-plant. At five locations per field, soil samples were taken at 5 inches intervals from the center of the bed to the center of the furrow in 60- and 80-inch bed fields. No general pattern of NO_3^- with regard to distance from the drip tape was observed, and no depletion of available phosphate and exchangeable potassium concentration was observed in the rooting zone around the drip tape. A soil sampling protocol valid for all the 16 fields was developed that identified the locations (i.e. perpendicular distance from the center line of a bed) and number of cores necessary to derive an estimate of soil NO_3^- content in the top 20 inches that did not differ >5% from the field average based on all the sampled locations in a given field. The soil samples collected in this manner could also be used to assess available phosphate and exchangeable potassium although the potential errors would be slightly higher (≤12%) in the case of available phosphate. At harvest, yields, N content of fruit and vines, and post-harvest nitrate levels in the top 10 inches of soil were measured. The apparent nitrogen (N) uptake efficiency defined as the ratio of whole plant (fruits and vines) N to available N (pre-plant nitrate and fertilizer N inputs) ranged from 0.15 to 0.64, while the crop N removal to fertilizer N input ratio ranged from 0.44 to 1.03. Five of the 16 fields had nitrate levels ≥200 lbs N per acre at pre-plant, while post-harvest nitrate content in the top 10 inches ranged from 43 to 392 lbs N per acre. These observations of high nitrate levels in some of the fields call for regular monitoring of nitrate concentrations using the protocol developed in this study and adjusting of fertilizer N inputs in order to decrease the risks of nitrate leaching in processing tomato fields.

CALIFORNIA TOMATO RESEARCH INSTITUTE, INC.

Project Title:
INVESTIGATION OF SUSTAINING TOMATO PLANT HEALTH AND YIELD WITH COMPOSTED MANURE

Project Leader(s)

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Ben Leacox, Field Assistant, UCCE.

Summary: Processing tomato yield responses to supplemental applications of 10 tons/acre of composted poultry manure were from 9 to 22%. Yield responses also occurred with supplemental applications of manufactured NPK at similar rates and placement to mimic nutrients in the composted manure treatment.

The results indicate yield increases may occur in soils with potassium levels below 200 ppm using an ammonium acetate extraction method and with potassium levels not exceeding 2% on the cation exchange capacity

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

Project Leader: Roger T. Chetelat
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Summary Project Report:

Acquisitions. The TGRC acquired three new accessions of the wild species *S. habrochaites* from previously unrepresented geographic regions of Ecuador. We also regenerated more wild species accessions that we formerly considered 'inactive' and had never been grown. Obsolete or redundant accessions were dropped. The current total of number of active accessions is 3,829.

Maintenance and Evaluation. A total of 2,420 cultures were grown for various purposes, of which 653 were for seed increase (153 of which were of wild species) and 1,008 for germination tests. Progeny tests were performed on 165 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 149 stocks, all of which were negative. 97 stocks were grown for introgression of the *S. sitiens* genome. Other stocks were grown 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 5,497 seed samples representing 2,046 unique accessions were distributed in response to 319 requests from 231 researchers and breeders in 33 countries; over 26 purely informational requests were also answered. The overall utilization rate (i.e. number of samples distributed relative to the number of active accessions) was 144%, showing that demand for our stocks remains high. Information provided by recipients indicates our stocks continue to be used to support a wide variety of research and breeding projects. Our annual literature search again uncovered a large number of publications mentioning use of our stocks.

Documentation. Our website (http://tgrc.ucdavis.edu) was updated in various ways to add features and address security issues. Our database was updated with more accurate collection site information for wild species such as *S. habrochaites* and the two Galapagos species. Our database was modified in various ways to improve internal record keeping related to seed requests, plant pedigrees, and seed lots. A dynamically generated 'reference' field was added that pulls key data from different fields, depending on the type of stock. This field provides a convenient short hand descriptor for each accession that can be used on pedigree sheets and seed request packing slips. A revised list of monogenic stocks was published in the Tomato Genetics Cooperative Report (http://tgc.ifas.ufl.edu).

Research. The TGRC continued research on the mechanisms of interspecific reproductive barriers and on introgression of the *S. sitiens* genome. We submitted a paper on the cloning of a pollen factor, *ui1.1,* one of two major genes that explain why pollen of cultivated tomato is rejected on flowers of most of the wild species. We

studied natural variation for pollen compatibility genes in self-compatible biotypes and species, and their role in transitions from outcrossing to inbreeding modes of reproduction. We further advanced a set of breeding lines representing the genome of *S. sitiens*, a species 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. In the first year of this project we focused on filling in gaps, i.e. identifying plants with introgressed segments in 'missing' regions of the genome, so that the resource will be as complete as possible.

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

CALIFORNIA TOMATO RESEARCH INSTITUTE, INC.
2014 ANNUAL SUMMARY REPORT

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

Objective:

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. We used marker-assisted selection to create a set of breeding lines containing different portions of this chromosome 9 region from *S. habrochaites*. In 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, maturity and plant weight (biomass). 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.

Summary:

We are using mRNA sequencing analysis to identify genes from *S. habrochaites* involved in resistance to water stress. We conducted replicated water stress experiments with two of our closely related breeding lines (Line 175 with an *S. habrochaites* segment from chromosome 9 and Line 163 without this segment) to induce expression of genes involved in water stress responses. Root samples from multiple plants of both lines were harvested at several time points in each experiment. RNA from the root samples were used to make mRNA-seq libraries that were sequenced on an Illumina Hi-Seq sequencer. We are analyzing the sequence read data for each sample with specialized statistical and bioinformatics programs. To date our results indicate that 53 differentially expressed transcripts (genes) map specifically to the *S. habrochaites* introgression contained in Line 175. The differentially expressed genes include amino acid binding proteins, transcription factors, kinases (protein regulatory), receptors and transporters. We are continuing our data analyses.

CALIFORNIA TOMATO RESEARCH INSTITUTE, INC.
2014 ANNUAL SUMMARY REPORT

Project Title: Marker genotyping of chromosome 9 from water-stress resistant wild tomato to generate breeding lines

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

Objective:

To use marker genotyping to generate a new set of breeding lines for chromosome 9 from wild tomato (*S. habrochaites*) that is associated with resistance to water stress and other horticultural traits.

Introduction:

Wild tomato (*S. habrochaites*) is highly resistant to water stress. We genetically mapped this resistance to the short arm of chromosome 9. Previously we used marker-assisted selection to create a set of breeding lines containing different portions of this chromosome 9 region from *S. habrochaites*. In 2012 and 2013, we conducted replicated field trials with 18 of these tomato breeding lines under two drip irrigation water treatments [full water, equivalent to the evapotranspiration rate (ETo) for tomato; and severely restricted water, 1/3 of ETo for tomato]. We measured various traits, including fruit yield, plant weight (biomass), delta C^{13} (a measure of water use efficiency), and specific leaf area (an indirect measure of leaf thickness, a trait associated with water stress tolerance). We found that all of these traits map to chromosome 9. Our results indicate that this portion of chromosome 9 contains genes controlling important traits, including traits associated with resistance to water stress. Furthermore, most of the traits mapped to one end (nearest the centromere) of the introgressed chromosome 9 region from *S. habrochaites*, suggesting that the genes controlling these traits are located very close to each other (e.g., closely linked). To unravel multiple traits controlled by closely linked genes, a new set of breeding lines containing chromosome segments that extend into this gene-dense region of chromosome 9 is needed.

Summary:

To select new breeding lines with *S. habrochaites* introgressions that extend towards the centromere of chromosome 9, we created and verified a new set of DNA markers. These markers are being used to genotype an advanced backcross generation segregating for chromosome 9 introgressions from *S. habrochaites*. Plants that contain unique chromosome 9 segments (i.e., recombinants) are being identified and selected. These are breeding lines that will be used in the future (*beyond* this project) for mapping traits associated with water stress tolerance on chromosome 9.

Project Title: Evaluation of tactics for improvement of stink bug control

Project Leader: Thomas A. Turini
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Co-Primary Investigators:

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SUMMARY

Populations of Consperse stink bug were dense in much of Fresno County in 2014 and were present at levels resulting in massive yield reductions in some areas. Attempts to locate overwintering sites in Winter 2013 were unsuccessful, but stink bugs in diapause were detected in Fall 2014 near an infested late-season tomato field. They were detected alone or in small groups of up to 16 in damp leaf litter. The area seems to be somewhat isolated and it does not extend throughout the permanent crop in which it was detected. In early 2014, stink bugs were first captured in pheromone-baited traps in mid-April. They reached detectable levels in a few commercial fields by 28 May. The densities remained high throughout the summer.
While the earliest detections of stink bugs were in traps, the traps failed to consistently represent the population densities present in the canopy at later stages of population development. This may suggest that the traps may have utility in detecting early stages of an infestation, but are not useful in quantification of the problem in a tomato field at later stages of an infestation. In insecticide efficacy trials, Leverage applied at early stages of infestation and Thionex consistently provided excellent levels of control, as did Venom, Leverage applied at a standard interval, Danitol, Belay with Warrior, and Endigo CX. However, some of the materials did not deliver any reduction in the levels of stink-bug damaged fruit: Lannate/Asana, dimethoate and Dibrom. Drip applied neonicotinoid insecticides seemed to reduce the level of fruit damage; however, more work is needed to substantiate this unexpected result.

Project title: Application of a degree-day model and risk index to predict development of thrips and *Tomato spotted wilt virus* (TSWV) and help implement an IPM program in California processing tomato fields

Principal investigator: **Robert L. Gilbertson**, Professor of Plant Pathology, Department of Plant Pathology, UC Davis

Cooperating personnel: **Ozgur Batuman**, Project Scientist, UC Davis; **Li-Fang Chen**, Project Scientist, UC Davis; **Brenna Aegerter,** Farm Advisor, San Joaquin County**; Neil McRoberts**, Epidemiologist, UC Davis and **Diane E. Ullman**, Entomologist, UC Davis

Summary

The goal of this project is the continued development and implementation of a predictive thrips phenology (degree-day) model and *Tomato spotted wilt virus* (TSWV) risk index (TRI), and to complete our ongoing thrips and TSWV monitoring efforts in San Joaquin and Contra Costa Counties (hereafter referred as San Joaquin County or SJC). The long-term goal of this research has been 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) program developed through this project. In 2014, monitoring of tomato fields in San Joaquin County revealed similar thrips population dynamics as in 2013 in which thrips populations started to build-up in early April and rapidly increased to high population levels by early- to mid-May. Populations remained high through the summer, and began to decline in late summer to early fall (late August to early September). However, in 2014, the build-up of thrips populations began earlier than in 2013. TSWV was first detected in a monitored direct-seeded tomato field on 3 April in the Byron area in SJC. TSWV was eventually detected in all monitored fields, but overall incidences were low (<1-4%). Slightly higher incidences (up to 7%) were found in parts of two fields (the direct-seeded field in Byron and another field in the Tracy area) by early June, but economic losses were not experienced. Winter and spring weed surveys revealed very low levels of TSWV infection (~2%). In 2014, the newly identified TSWV weed host, rough-seeded buttercup (*Ranunculus muricatus*), was again widespread in walnut orchards and some plants were infected with TSWV. 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 up to 8 weeks and that many of the emerging adult thrips (62-100%) transmitted TSWV. These results strongly suggest that adult thrips, emerging from soil, can be an early season TSWV inoculum source. During the 2014 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 predicted the appearance of adult thrips generations with >80% accuracy. Thus, this model can be used as a predictor of when thrips populations begin to increase in the spring, and can help identify when to start implementing thrips management strategies (e.g., early- to mid-April in SJC in 2014). 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 were able to submit required field information interactively to the TRI calculator and received a prompt response with the TRI value for their field (low, moderate or high risk) and recommendations on how to minimize TSWV risk. The TRI for the monitored fields in SJC was moderate, and this was consistent with observed disease levels. The IPM program for thrips and TSWV developed through this project can provide effective disease management, particularly if implemented on a regional level. We will continue to encourage the use of the grower-friendly thrips degree-day model and risk index, and publicize the IPM program for thrips and TSWV management.

Title: Evaluation of Fungicides, Bio-Pesticides and Soil Amendments for the Control of Southern Blight in Processing Tomatoes.

Project Leader: Joe Nunez, Vegetable/Plant Pathology Advisor, U.C. Cooperative Extension, 1031 So. Mount Vernon Ave., Bakersfield, CA 93307. Office: 661-868-6222, Fax: 661-868-6208,
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Co-Investigators: Mike Davis, Plant Pathology Specialist, Department of Plant Pathology, University of California, at Davis, CA 95616. Office: 530-752-0303, Fax: 530-752-1199, Email: rmdavis@ucdavis.edu

In 2014 seven (7) separate trials were conducted in a grower's field infested with Sclerotium rolfsii (Table 1). The trials included a Metam-sodium fumigation trial, fungicide trial, lime trial, variety trial, biological trial, systemic acquired resistance (SAR) trial and an SAR plus fungicide trial.

Unfortunately no data was able to be collected from these trials because nearly every plant succumbed to Southern Blight infection and/or "Curly Top". This demonstrates just how difficult this pathogen is to control and how potentially devastating it can be to the processing tomato industry.

Research Project Report 2014
California Tomato Research Institute, Inc.

Project Title: Evaluation of New Nematicides Against Root-Knot Nematodes in Processing Tomato Production

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 University of California South Coast Research and Extension Center (SCREC) and at Shafter to evaluate the efficacy of several novel soil nematicides 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 a non-treated control served as standard checks. Of the products tested, three nematicides showed good to excellent efficacy against the Southern root-knot nematode *Meloidogyne incognita*. At SCREC under high root-knot nematode disease pressure MCW-2 lowered root galling ratings at mid-season from 4.5 in the control to 0.8 and 1.5 in the high and low rate of MCW-2, respectively. At harvest the gall rating dropped from 9.1 in the non-treated control to 3.4 and 4.2, respectively. The high rate increased tomato yields by 43% over the non-treated check. This product has recently received federal EPA registration for fruiting vegetables. Another development product (Dp1) that was noted for its promising activity in our 2013 trials, again showed excellent efficacy. It reduced mid-season galling from a rating value of 4.5 in the non-treated control to about 1.0 in the Dp1 treatment. At harvest, root galling was limited to a 2.2 rating. This was reflected in increased tomato yields over the non-treated control by approximately 65%. The third development product (Dp3) became available shortly before initiation of the trials; consequently we lack experience in its optimal use. Although gall reduction was slightly less than with the other two products, there was a strong yield response with 40% over the non-treated control.

The Shafter trial suffered from curly top incidence but still confirmed the excellent nematicidal efficacy of MCW-2 and DP1 based on root gall ratings. None of four other tested development products showed significant efficacy against root-knot nematodes.

The Effect of Cover Crops, Compost, and Gypsum Amendments on Soil Structure and Disease in Processing Tomatoes

Project Leader: Kate Scow, Professor,
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Collaborators:
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Mike Davis, Professor, Plant Pathology, Cooperative Extension Specialist, UC Davis
Sharon Dabach, Post Doctoral Scholar, UC Davis Viticulture and Enology, UC Davis
Steven Fonte, Researcher, Department of Plant Sciences, UC Davis
Gene Miyao, Farm Advisor Vegetable Crops, UC Cooperative Extension, Yolo County

Summary of Results:

Amendments such as compost, cover crops, and gypsum have the potential to improve soil structure, improve soil water relations, and to reduce plant damage from pathogens to increase tomato yield. In this year's study of amendments at Russell Ranch, and in grower Steve Meek's field, we observed how amendments can modify the soil to improve yield and plant health. In this study, yields at Russell Ranch were highest in compost alone treatments and were lowest in treatments with cover crops. Cover crop treatments also resulted in lower bulk densities. Sodium, phosphorus, and potassium were significantly higher in compost treatments, and SO_4-S was significantly higher for gypsum treatments. Foster Farms compost amended soils had significantly higher SO_4-S levels with a lower pH, and Jepson Prairie compost had higher levels of calcium in amended soils than control and OLAM amended soils. Saturated hydraulic conductivity was lower in the compost, gypsum, and cover crop treatment than the control and compost with cover crop treatments at Russell Ranch. The compost, gypsum, and cover crop treatment in the grower's field also has a significantly lower hydraulic conductivity than treatments of cover crop and compost alone. For the second year, beds amended with compost had less disease damage in the August observations before harvest compared to non-compost amended soils. In light of the benefits of these amendments, it will be necessary to compare changes in yield, soil structure, and disease with the cost of amending soils to decide whether or the amendments would be economically beneficial to use.

2014 Annual Progress report

Project Title: Genome sequencing of the bacterial canker pathogen, *Clavibacter michiganensis* subsp. *michiganensis*, to develop robust detection and disease control strategies.

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Summary
Over the last two years we have significantly updated the knowledge base concerning *Cmm* in California. The whole genome study has shown that *Cmm* strains are genetically different from the type *Cmm* strain, which may reflect adaptation to different climatic or environmental conditions. Genome sequence information was used to design highly specific and sensitive primers for PCR detection of *Cmm*. The genome sequences will also help us understand the changes undergone at the gene level and how these changes have impacted *Cmm* virulence and survival in California. This information can also be employed to develop a more robust detection system and a control strategy for bacterial canker of tomato

Project Title:
Detection of azole and strobilurin fungicide resistant strains of tomato powdery mildew in California

Project leader:

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Abstract:
Powdery mildews are obligate biotrophic fungi that cause extensive diseases in crops. In tomatoes, powdery mildew infections are caused by the species *Leveillula taurica* and *Oidium neolycopersici*, which are primarily associated with the disease in field and greenhouse grown tomatoes, respectively. The goal in this research was to investigate whether the continuous use of azole and strobilurin fungicides in tomato fields in California has sparked the appearance of resistant strains of *L. taurica* and *O. neolycpersici*. Knowledge on the presence and distribution of fungicide resistant strains will help design a strategy for preventing further spread of such strains. Since resistance development is frequently correlated with mutations at the target site of the fungicides, to achieve our goal we followed an approach of first cloning and subsequently screening in *L. taurica* field populations, for mutations in the *CYP51* and *cytb* genes that encode for the enzymatic targets of azole and strobilurin fungicides, respectively. Analysis of the mitochondrial cytochrome b gene (*cytb*) showed that strains with mutations conferring resistance to strobilurins, such as the notorious G143A mutation, are already widely present in fields. However, the analysis also indicated that the presence of this mutation in field strains of *L. taurica* is associated with mitochondrial heteroplasmy for the *cytb* gene, suggesting that resistance in the fields is not yet complete but rather correlates with the portion of mitochondria in each strain carrying the mutated *cytb* allele. In contrast, no mutations were identified so far in the *CYP51* gene of *L. taurica* populations collected from the fields in 2014. The characterization of these two genes from *L. taurica* sets the scene for monitoring shifts in fungicide sensitivity in populations of the fungus.

2014 Annual Progress Report

Project Title: Curly Top Research in Response to the 2013 Outbreak in Tomato in the Central Valley of California: Objectives Relevant to Tomatoes

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Introduction:

The 2013 outbreak of curly top disease in processing tomatoes caused losses of ~$100 million, and was a reminder that curly top disease can still cause substantial economic losses to this crop in California. Furthermore, this outbreak occurred despite the ongoing insecticide spray program for the beet leafhopper vector that is carried out by the CDFA curly top virus control board (CTVCB). The factors responsible for the 2013 outbreak are not known, but leafhopper populations early in the year were unusually high and most of these insects carried a high level of curly top virus. Thus, given the severity of the 2013 curly top outbreak, a research project was initiated to further investigate the disease, including aspects of the leafhopper vector and the *Beet curly top virus* (BCTV). The long-term goal of this research is to develop an effective curly top virus integrated pest management strategy that targets multiple points in the disease cycle rather than only one (the leafhopper vector). Furthermore, the availability of new biotechnological tools for detecting BCTV (PCR and DNA sequencing) and screening plants for resistance to BCTV (agroinoculation) allows for new approaches to disease management.

Because curly top is a disease of crops other than tomato and the proposed research to address the 2013 curly top outbreak involves objectives that specifically involve tomatoes and others that involve all crops, the research tasks and funding for this project were divided between CTRI (objectives related to tomatoes) and the CTVCB (objectives related to all crops). The objectives of the CTRI-funded curly top virus research are to 1) further assess the level and nature of resistance to curly top in a tomato breeding line and other tomato germplasm possessing genes known to confer resistance to whitefly-transmittted geminiviruses, 2) assess the level of curly top in processing tomatoes in 2014 and the associated BCTV strains of the virus, and 3) assess the potential for developing novel strategies for interfering with leafhopper feeding on tomato plants.

CALIFORNIA TOMATO RESEARCH INSTITUTE, INC.
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Project Title: EVALUATION OF CHEMICAL CONTROL OF BACTERIAL SPECK

Project Leader(s)

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Objectives: Evaluate foliar applications of chemicals for bacterial speck control.

Background: Bacterial speck is often a problem when rainy, cool weather conditions persistent in the spring. Control has always been challenging when multiple rain events trigger the onset and development of the disease. Plant resistance that once was effective has been overcome. Most spray control programs are based around the use of copper, which has provided moderate control at best.

Procedures: Two field tests were established: one in eastern Contra Costa County (Brentwood/Byron area) with Simoni & Massoni and in western Yolo County with Muller Farms.

Materials included Kocide, Dithane, Actigard, Oxidate, Regalia, Agriphage and Serenade Max (Table 1). All included copper as a tank mix except the Agriphage treatment. A minimum of 4 applications were made during the season. Sprays were applied with hand-held equipment. A non-ionic surfactant was included in all sprays except for the Agriphage treatment in Brentwood.

Disease development was minimal at the Brentwood site and none was detected at the Yolo site. Several rain events occurred (9 in Brentwood and 4 in Yolo) but weather conditions in general were not conducive for disease development.

FINAL REPORT TO THE CALIFORNIA TOMATO RESEARCH INSTITUTE

Project Title: Synergy-based biocontrol of Fusarium wilt of tomato

Project Year: 2014
Project Leader: Johan Leveau, Associate Professor, Department of Plant Pathology, One Shields Ave, University of California, Davis, CA 95616. E-mail jleveau@ucdavis.edu. Telephone (530) 752-5046.
Budget: $39,993

Key findings/accomplishments:

• We demonstrated in a field setting the protective effect of *Colli*nade (a mixture of *Collimonas* bacteria and Serenade Soil) against *Fusarium oxysporum* f. sp. *lycopersicum* (FOL), causative agent of Fusarium wilt of tomato.

• We showed that this effect (a reduction in FOL-induced vascular discoloration and declining shoot biomass) was unique to the mixture, i.e. *Collimonas* or Serenade Soil alone did not achieve this effect.

• *Colli*nade also protected approximately 1 ton of fruit per acre from FOL-related sunburn damage, presumably by supporting a thicker canopy.

• We developed a microcosm assay that allows rapid, medium-throughput laboratory screening of single or mixed biological agents (including variations on *Colli*nade) for ability to prevent FOL infection of tomato seedlings.

• We have presented our *Colli*nade results to various commercial companies, and are actively seeking their interest in funding follow-up research on the practical application and mechanisms of the *Colli*nade or 'biocombicontrol' principle.

This final report covers the period between January 1, 2014 (project start date) and November 7, 2014 (final report due date). We were granted a one-year extension on the project, so that the official end date for the project is now December 31, 2015. This extra time will allow us to perform several repetitions or variations of experiments described in this report, with the goal to further substantiate our claims as explained in the full version.

CALIFORNIA TOMATO RESEARCH INSTITUTE, INC.

Project Title: EVALUATION OF ROOT KNOT NEMATODE CONTROL WITH RESISTANT WHEAT CULTIVAR AND VARIOUS COVER CROPS

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Summary: Nematode resistant wheat cultivar Patwin reduced root knot nematode population levels substantially when grown in a heavily infested soil as a cover crop prior to growing tomatoes, but the reduction was not sufficient in this case to elevate tomato yields above the non-treated control. Patwin wheat, in our field test, did not reduce *Meloidogyne incognita* population levels satisfactorily.

Objective: Evaluate the influence of root knot nematode resistant wheat cultivar on Mi-resistance breaking nematode populations in a field test.

Results: Grass growth started slowly due to low rainfall, but with supplemental irrigation produced from 1.6 to 2.3 ton per acre (Table 1). All grass crops lowered nematode soil levels compared to the fallow control when sampled in the spring prior to the tomato planting (Table 2). Levels in the spring were reduced to 7 to 29% of the population in the fall. The levels were 42 to 124 J2 juveniles compared to 364 per 100 grams of soil in the non-treated control. Results from the soil samples at tomato harvest are pending. Tomato root galling was severe at end of the season average about 8 on a scale of 0 to 10, where 8 is defined as 'all main roots knotted with few clean roots visible' from a visual rating scale.

Tomato fruit yields from all the grass treatments were lower than the control, averaging 28.0 vs. 38.8 tons/acre, respectively (Table 2). The resistant wheat Patwin did not improve tomato yield when planted ahead of tomatoes as a cover crop although soil sample indicated levels were reduced compared to the control.

TITLE: Field Bindweed Management in Processing Tomatoes

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SUMMARY (tables in the full version)

In order to maximize yield, tomatoes must remain relatively weed-free for up to two months after planting. Results from the 2014 CTRI sponsored research trial agree with those achieved in 2013, namely, that the use of a diverse herbicide program can effectively suppress field bindweed and other troublesome weed species common to processing tomatoes (Table 4). The use of a glyphosate burn-down treatment one to two weeks prior to bed-shaping can improve the management of severe field bindweed infestations. When averaged over all herbicide programs, glyphosate reduced field bindweed cover, in-crop by 50% at six weeks after transplanting. Although *S*-metolachlor, sulfentrazone or rimsulfuron are effective against nutsedges and small-seeded broadleaved weeds, trifluralin appears to be predominantly responsible for the suppression of field bindweed. The use of rimsulfuron (POST) or carfentrazone (SHIELD) can be effective for managing field bindweed, their utility is most likely to be maximized when additional measures are also undertaken (i.e. burn-down and PPI/PRE) applications. Results from this research trial show that successful field bindweed suppression is likely to be achieved when multiple control strategies are employed.

The research trials from 2013 and 2014 are currently being written up as a manuscript that will be submitted to the peer-reviewed journal, Weed Technology. This data will also be developed into a weed science blog (http://wric.ucdavis.edu/) for California processing tomato growers.

Project Title:
Evaluating Herbicide Carryover in Sub-surface Drip-irrigated Tomatoes

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Summary:
The second season of a three-year field trial was conducted at the UC West Side Research & Extension Center in Five Points, CA to evaluate Treflan (trifluralin) and Prowl H_2O (pendimethalin) carryover and potential impact on tomato health and production in a three-year tomato rotation using sub-surface drip irrigation. In spring 2014, residues of trifluralin (up to 0.006 ppm) and pendimethalin (up to 0.031 ppm) were detected up to six inches deep in the soil one year after their application in 2013, with at least 3X more pendimethalin detected than trifluralin. The potential for herbicide carryover, particularly with pendimethalin, seemed to be aided by the dry winter (<2.6″ total rainfall) we had during 2013/14. However, herbicide residue levels detected did not result in reduced tomato plant dry weight or fruit yield. Following re-treatment in 2014, using sprinkler water to wet the bed surface helped reduce the amount of detectable trigluralin by 95% by harvest, compared to 88% for pendimethalin, which was similar to what we saw in 2013. Based on residues detected at the end of 2014, we expect to see an accumulation of pendimethalin in 2015, above 2014 levels, especially if rainfall is again lacking during the winter. If this is the case, we might also expect to see phytotoxic effects from the pendimethalin on tomato growth and yield potential.