

strain was infecting these tomato samples and we found that the samples from the Central Valley were infected with the CFH strain, whereas the samples from Southern California were infected with the Worland strain, which is the same strain we have found to infect pepper in California. Thus, our results demonstrate the presence of two CTV strains infecting tomato in California in 1997, and at least one of these is also known to infect pepper.

The Worland strain of CTV has been demonstrated to cause pepper curly top in California, and additional characterization of a Worland CTV isolate from pepper has indicated that it is very similar to the Worland strain that originally came from sugar beet. Thus, this pepper isolate of the Worland strain of CTV was selected for screening peppers for CTV resistance. We generated an infectious cloned DNA copy of this CTV isolate and demonstrated it could infect and cause curly top in peppers, tomatoes, and

tobacco using the gene gun to introduce this DNA into plants.

We also found that the gene gun technique was very efficient for introducing CTV into tobacco plants, but that it was not very efficient at introducing CTV into pepper or tomato. A double (dimer) copy of this DNA was prepared, confirmed to still be infectious, and was transferred into the bacterium, *Agrobacterium tumefaciens*, which can transfer the DNA into the plant and thus initiate CTV infection. Although we confirmed that the CTV DNA was introduced into the bacteria, plants inoculated with the bacteria failed to become infected. We found that this was due to a rearrangement of the DNA inside the bacteria, which resulted in the deletion of part of the CTV DNA. To get around this problem, a new construct needs to be generated that has less chance of such a rearrangement occurring.

As part of a separate project, we were able to get an *Agrobacterium*-based inoculation system working with a whitefly-transmitted geminivirus pepper huasteco virus (PHV). We have successfully infected peppers using this system, which demonstrates that agroinoculation can be successfully used for peppers. Thus, once the CTV agroinoculation system is up and working, we anticipate that it should work in pepper. At the same time we will be able to evaluate pepper germplasm for resistance to both the leafhopper-transmitted CTV and the whitefly-transmitted PHV.

The low incidence of CTV in peppers over the past 3-4 years, for whatever reason, has clearly minimized the importance of this virus to peppers in California. Also, whitefly-transmitted gemini-viruses, such as PHV, are problems in Mexico and other pepper-growing regions, but not in California. Thus, it was decided not to continue to fund this work in 1998-99. While we understand the reasons for this decision, we regret that we will not be able to complete the final objective of our project, the screening of pepper germplasm for CTV resistance. However, we do feel we 1) developed effective tools for CTV detection and characterization in pepper and other crops, 2) identified the CTV strain infecting pepper in California and 3) generated an infectious clone of the pepper-infecting CTV that can be used for screening pepper germplasm for CTV resistance at a future date.



Pepper News

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ANNUAL REPORT ISSUE

Commission Report

The Pepper Commission has just completed its ninth year of operation, and the research summaries contained in this issue of its Annual Report show that it is continuing in its efforts to find solutions to the production problems of the California pepper industry. This annual newsletter contains a financial report for the past year, as well as reports of the Commission's production research projects that were funded during the 1997-98 fiscal year. Also included is the Commission's new membership roster as of the beginning of its fiscal year which began on May 1, 1998.

Steve Banta served as Commission Chairman during the 1997-98 year, but because of a change in his occupation, was not elected as a Commissioner to represent the industry for the next three-year term. Instead, Banta was selected by the Commission as an Alternate Public Member, and will continue to serve the industry from that vantage point for the next three-year term of office.

At its April meeting, in Banta's place as Chairman, the Commission elected Glen Fischer of Saticoy, with Mike Chuck serving as Fischer's Vice Chairman. Chuck, a grower from Gilroy, is one of several new Commissioners who were named to serve new three-year terms in this February's election. Other industry members serving for the first time on the Commission are growers Tom Glau of San Ardo, Ryan Talley of Arroyo Grande and Chris Garcia of Lompoc. New handler representatives on the Commission for the 1998-2001 term are Everett Wood of Santa Ana and Tom Day of Morgan Hill.

The Financial Report on Page 6 shows the Commission is still in excellent financial shape, with the income from marketed peppers increasing each of the past three seasons. Over the past six years, in an attempt to be conservative, the Commission has budgeted on the basis of receiving income from the equivalent of 270,000 tons of fresh peppers, which would bring in \$135,000 at the \$.50 per ton rate. However, the actual income during those years has ranged from a low of \$149,772 in 1993-94 to a high of \$182,644, recorded in 1996-97. Last year's wasn't quite so high, but was still more than \$35,000 above the budgeted \$135,000. With the crop size continuing to be above the budgeted level, the Commission has been able to carry over those surpluses from year to year, thus making it somewhat easier to fund the needed research projects.

Insofar as the Commission's expenditures during the 1997-98 year were concerned, they were entirely within the budget and the Commission earned almost \$7,800 in interest on its reserve funds. The Commissioners have always prided themselves on squeezing the last ounce of usefulness out of each dollar collected from the industry, and last year they were again able to show that over 75% of the Commission's expenses went directly to research projects, with less than 25% spent on overhead items, which include the management, as well as the California Department of Food & Agriculture's monitoring of the Commission's activities.

During the 1997-98 year, the Commission funded six research projects costing a total of \$123,683, and the layman's reports for those projects are included with this report. Anyone wanting copies of the full technical report of any of the projects can obtain a copy by calling or writing the Commission office.

California Pepper Commission

Financial Report

Fiscal Year: May 1, 1997 through April 30, 1998

Account Name	Amount
INCOME	
Carry-over from 1996-97	\$129,034
Assessment Income, 1997-98	170,544
Assessment Income, Prior Years	2,777
Interest Income	<u>7,797</u>
Total Income	\$310,152
EXPENDITURES	
Management Services	\$28,800
Legal Counsel	1,851
Audits	1,656
Office Supplies	1,726
Telephone	405
Postage	897
Travel & Mileage	381
Meetings	518
Insurance	654
Marketing Branch, CDFA	5,394
Production Research	<u>128,683</u>
Total Expenditures	\$170,968
Carry-over to 1998-99	<u>139,187</u>
Total Expenses & Reserve	\$310,152

California Pepper Commission

☐☐ PRODUCER REPRESENTATIVES ☐☐

Members	District	Alternates
Tom Glau San Ardo 408/627-2080	1	Burt Silva King City 408/385-1428
Ryan Talley Arroyo Grande 805/489-2508	2	Chris Garcia Lompoc 805/736-1663
Mike Chuck Gilroy 408/848-6373	3	Mike Mantelli Gilroy 408/848-9228
Bob Giampaoli Le Grand 209/389-4576	4	Joe Marchini Le Grand 209/389-4528
Randy Johnston Lemoore 209/924-5339	5	Richard Bradford Coachella 760/399-4278

☐☐ HANDLER REPRESENTATIVES ☐☐

Classification

Dave Veneman Escalon 209/838-4040	Bell Pepper Processing	Tom Busenbark Modesto 209/538-5437
Everett Wood, Santa Ana 714/775-9354	Dehydrated Chili Peppers	Paul Gniffke Greenfield 408/674-5571
Glen A. Fischer Saticoy 805/647-5266	"Other" Pepper Processing	Vacancy
Tim Baloian Fresno. 209/485-9200	Fresh Pepper Handler	Wally Miller Lodi 209/334-3173
Robert Heisey San Juan Bautista 408/623-4554	Pepper Seed Handler	Tom Day Morgan Hill 408/778-7758

☐☐ PUBLIC REPRESENTATIVES ☐☐

Don Nelson Mokelumne Hill 209/754-5605	Steve Banta Paso Robles 805/237-2430
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Development of Improved Sources of Resistance & Selection Strategies for Resistance to Pepper Viral Diseases

Dr. Molly Kyle Jahn, Assistant Professor, Department of Plant Breeding & Biometry, Cornell Univ.

This reports marks the completion of the fourth year of a pepper breeding program to improve the level of resistance to symptoms caused by infection by cucumber mosaic virus (CMV) using the two leading sources of CMV tolerance (CMR): *C. annuum* 'French Perennial', a Perennial line obtained from INRA, France that compared favorably with other versions of Perennial for stability and uniformity of CMR; and *C. frutescens* 'BG2814-6'. We are using as recurrent parents the Rogers hybrid 'Verdel' (bell); 'CalCompak 648' (Anaheim) provided by Paul Narewski, and a potyvirus-resistant jalapeno provided by Ken Owens, selected out of material bred by Dr. Ben Villalon.

Our disease screening procedure results in very intense exposure to the disease, judged by the severity of symptoms on susceptible check plants and the fact that the frequency of check plants that escape infections is essentially zero. Resistance from both the *C. annuum* and the *C. frutescens* sources refers to the failure to develop symptoms. Although virus titer also appears to be substantially reduced relative to fully susceptible genotypes, virus is generally present at levels that are higher than uninoculated controls in symptom-free or nearly symptom-free plants. To reflect this, we refer to materials we are developing as "tolerant" to infection by the virus, and resistant to the disease.

As part of a related project undertaken in our lab to characterize the inheritance of resistance in *C. frutescens* 'BG2814-6', we have learned that the resistance is recessive and is controlled by at least two genes. We are still working to clarify the relationship between the resistance genes in the *C. annuum* and *C. frutescens* sources, but we have at least two lines of evidence suggesting that there are distinct genes in the two sources.. In 1997 we found that it was important to screen F₃ progeny in order to accurately identify resistant F₂ plants used for backcrossing, because in

the range of virulence in pepper as well as tomato isolates on both pepper and tomato. On tomato, both pepper and tomato isolates caused wilt to the same degree, but on pepper, not all pepper isolates were equally virulent. Two isolates that came from bell pepper severely stunted pepper plants and prevented flower and fruit formation. The two isolates from Anaheim peppers exhibited intermediate virulence.

We also challenged a few advanced breeding lines from Dr. Bosland's program to pepper isolates from California. The breeding lines and the susceptible controls were equally susceptible to California isolates.

Epidemiology of Pepper Stip

Richard Smith & Bob Mullen, Farm Advisors in San Benito & San Joaquin Counties, and Tim Hartz, Vegetable Specialist, Department of Vegetable Crops, U.C. Davis

Pepper stip causes gray-brown to greenish spots 1/4 to 1/3 of an inch in diameter. The spots extend from the surface to the interior of the pod and are most frequently seen on mature red fruit. Growers can suffer significant losses due to this malady. It has been determined that pepper stip is not caused by a disease, virus or insect feeding. It appears to be a physiological disorder that is brought on by weather and nutritional factors. Open pollinated varieties are more susceptible to the problem than hybrids.

Earlier studies have indicated that pepper stip-resistant varieties maintain significantly more calcium and less potassium in the leaf tissue of the plant than susceptible varieties. In addition, it was observed in laboratory studies that high levels of nitrogen were associated with increased pepper stip symptoms, especially under low light conditions. As a result, the objective of the 1997 studies was two fold: 1) continue to examine the effect of improved calcium nutrition on the incidence of pepper stip and 2) test the effect of various levels of nitrogen nutrition on the incidence of pepper stip. One field trial was established in San Joaquin County to examine the use of soil applied calcium and foliar applications of calcium materials, and two field trials were established in San

Benito County to examine the effect of various rates of nitrogen on the incidence of pepper stip.

Calcium applications either as a preplant gypsum application or as a foliar application reduced the incidence of pepper stip to moderate levels in the San Joaquin County trial. These results are encouraging and these studies will be repeated in 1998 to further verify the results. In the nitrogen nutrition studies, the high nitrogen treatments increased levels of potassium and decreased levels of calcium in the leaf tissue. This is the same relationship between potassium and calcium that we have observed over the past two years in pepper stip susceptible varieties indicating that high nitrogen was making the plants more susceptible to stip. However, we did not see increased levels of pepper stip in the high nitrogen treatments over the low to moderate nitrogen fertilized plots. These results strongly indicate that it may not be possible to reduce the incidence of pepper stip by simply manipulating fertilization rates.

Detection of Curly Top Virus in Peppers and Screening Peppers for CTV Resistance

Dr. Robert L. Gilbertson, Department of Plant Pathology, U.C. Davis

The overall objective of this project was to identify and characterize the type (strain) of curly top virus (CTV) that infects peppers in California and to develop an efficient method for screening peppers for curly top resistance that does not involve the use of the leafhopper vector. We developed a number of tools (DNA probe test and more recently a PCR [polymerase chain reaction] test) that allow us to detect curly top virus in pepper tissues in as little as 5-6 hours and, in a matter of days, allow us to determine the curly top strain infecting pepper or other crops.

In 1997, the overall incidence of CTV in pepper was again low (as it has been for the past three years), and the few samples of peppers received for testing were not infected by the curly top virus. We did receive a number of tomato samples from the Central Valley and Southern California for CTV testing, and these were found to be infected with CTV based on our PCR test. We determined which CTV

all genetic backgrounds and in all types of pedigrees, some phenotypically resistant F₂ individuals gave rise to less than 25% CMT (cucumber mosaic tolerant) progeny. We also see incomplete penetrance of full tolerance to cucumber mosaic disease in the *C. frutescens* source, even with lines that have been through several rounds of self-pollination after rigorous selection.

During this year of the project, we screened large BC₂F₂ (bell and jalapeno) and BC₂F₁ and BC₁F₂ (Anaheim) populations sent to us by our cooperators in California, produced from seed we had provided earlier in the year. This seed was planted during the winter in Ithaca, inoculated, and we have selected the most promising plants for selfing and further backcrossing. Our cooperators have agreed once again to plant BC₃F₁ (bell and jalapeno) and BC₂F₁ and perhaps BC₃F₁ (Anaheim) in California in the summer of 1998.

We plan trials of advanced CMT jalapeno populations in California this summer, and if they perform as we expect and are acceptable for type, we will plan to release this material which should combine tolerance to CMV with potyvirus resistance to the industry during the next calendar year.

Evaluation of Germplasm, Improvement of Pod Types, & Host-Specificity of Verticillium Wilt in Peppers

Mary K. Riley, Research Assistant and Paul W. Bosland, Professor; New Mexico State University Department of Agronomy & Horticulture

Verticillium dahliae is a soil-borne fungus that causes the disease Verticillium wilt on peppers. In pepper fields infested with the fungus, yield losses range from 20 to 90%. Once the soil has been invaded by the fungus, the resting spores (microsclerotia) can survive in the soil for up to 20 years, making crop rotation an unreliable method of control. Biological control, using other fungi or bacteria to attack *Verticillium*, has not been successful, and soil fumigation and chemical applications are

not economically practical for the grower. Therefore, production of resistant varieties is the best approach for controlling Verticillium wilt of peppers.

The Pepper Breeding Program at New Mexico State University developed a pepper line with 75% resistance. This line was crossed to commercial lines of jalapeno, bell, and New Mexican pod types. Plants produced from these crosses did not possess a stable level of resistance. In an effort to find a better (stronger and more easily transferred) source of resistance, hundreds of peppers from many *Capsicum* species were evaluated. From these tests, several lines consistently exhibited high levels of resistance (>75%). Plants from these lines were then crossed with plants from the original resistant source. It is anticipated that offspring from these crosses will have increased resistance to Verticillium wilt. Pepper lines from *C. frutescens*, the tabasco species, were highly resistant and, a few of the lines were resistant when retested.

Peppers and tomatoes are often grown in the same fields (although not in consecutive years) and Verticillium wilt is an economic problem on both crops. There is contradictory evidence about whether the *Verticillium* strain that infects peppers will infect tomatoes, and vice versa. Therefore, a series of tests checked for cross-infectivity. Four *Verticillium* strains (two from pepper: a new Mexico strain and a California strain; and two from tomato: one race 1 and one race 2) were tested on pepper and tomato plants. The results from these tests revealed that no cross-infectivity occurred with any of the isolates. Tomatoes were not infected by either pepper strain and peppers were not infected by either tomato strain. This will allow growers to plant tomatoes in a field known to be infested with the pepper strain of *Verticillium* and to plant peppers in an infested tomato field.

An unexpected result from these tests was the discovery that the two pepper strains were actually two different races. This was confirmed by the behavior of the resistant line. This line was resistant when inoculated with the New Mexico *Verticillium* strain, yet susceptible when inoculated with the California strain. This is the first report of a second race of *Verticillium Dahliae* on peppers.

Strategies to Control Powdery Mildew

Richard Smith & Frank Laemmlen, Farm Advisors in San Benito and Santa Clara Counties and Krishna Subbarao, Plant Pathology Specialist, U.C. Davis Plant Pathology Department

Powdery mildew continues to be a significant problem for peppers in many parts of the State. It has infected peppers in all production districts, but its severity varies from year to year, depending upon the weather conditions. It has been under control due to awareness of the disease and through careful use of Rally which was available under an emergency Section 18 registration in 1997. The goal of this project has been to identify techniques and fungicides to control the disease.

Over the past several years we have screened a large number of fungicides for efficacy against this disease. Sulfur has been shown to control powdery mildew in small plots in the coastal production districts if it is applied prior to the onset of the powdery mildew and when applied four to six times during the season. One disadvantage to the use of sulfur is the restriction to its use at temperatures below 90° F. Good coverage is critical to the efficacy of sulfur, but ground applications are difficult to make later in the season once the canopy has closed over the furrows. In the 1997 trials we examined the efficacy of aerial applications of sulfur. These applications provided good control early, but the protection broke down later in the season. As a result, most growers have found it difficult, if not impossible, to rely exclusively upon sulfur as the sole control material for powdery mildew.

There are three materials that provide excellent control of pepper powdery mildew:

1) Rally (Rohm and Haas) -- It has been registered under a Section 18 and efforts are underway to secure a full registration under the IR-4 project.

2) Tilt (Novartis); and 3) Folicur (Bayer). -- These materials are not registered and there currently are no plans to pursue registration. Other materials

that currently have registrations for use on peppers include Trilogy and Copper. However, neither of these materials are efficacious against the disease.

Varieties that are resistant to pepper powdery mildew will probably be available in the future and could then be used as a control strategy for this disease. At present, however, there are no commercial lines that have this resistance.

Biology of Verticillium Wilt of Pepper

Krishna Subbarao, Associate Plant Pathologist/CE Specialist, Plant Pathology, UC Davis

This project was initiated in 1996 to understand the biology and epidemiology of Verticillium wilt to develop long-term strategies for its management in pepper and to complement the ongoing breeding program on wilt resistance in pepper. The objectives during 1997-98 included: a) assessing the severity of Verticillium wilt on pepper in coastal California and determine the populations of microsclerotia in soil; b) determine the cross-pathogenicity of *Verticillium dahliae* isolates from pepper and tomato on each other; and c) determine the differential virulence of *Verticillium dahliae* isolates from pepper.

The survey of pepper fields for Verticillium wilt both in the San Joaquin Valley and coastal California was continued. Despite our best efforts, no Verticillium wilt was found in the San Joaquin Valley. In Coastal California, however, the disease appears to be on the increase. Verticillium wilt in the production fields varied between 6% and 99%. The pattern of disease distribution in these fields essentially confirmed last year's conclusions. Fields that were recently infested with *V. Dahliae* microsclerotia had the highest incidence at the edges of the fields and in fields with a long history of infestation, the disease incidence was uniformly high throughout the fields. These fields had an average of 5 to 30 microsclerotia per gram of dry soil.

Only pepper isolates were pathogenic on pepper. The two tomato isolates, while pathogenic to tomato, failed to infect pepper. We also determined