Phytophthora capsici, Cause of Root and Crown Rot of Tomatoes, Peppers and Squash

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Last year (2007) we saw a small epidemic of Phytophthora capsici in tomatoes and peppers that included a few fields on Roberts and Union Islands, some in the Tracy-area, and a few fields on the east side of the county. While there are other species of Phytophthora that can cause disease in each of these hosts, this species is fairly aggressive and can also cause a foliar blight if spores of the pathogen are splashed up onto the leaves or fruit and there is free moisture. This disease is particularly severe on peppers, and also on pumpkins and summer squashes. Unfortunately, Phytophthora capsici has a large host range which includes peppers, tomatoes, eggplants, squash, and other cucurbits such as melons, as well as the weed velvetleaf (doesn't seem to be hurting its reproduction though!). P. capsici is a soil inhabitant and forms survival structures (oospores) which are long-lived in the soil.

Symptoms.

P. capsici can cause damping-off of direct seeded crops. With transplants, you may see a rapid death of the young plants. Established plants will exhibit a crown rot and dramatic wilt; older plants may survive but yield will be reduced. Stems are usually infected at the soil line, but stems can also be infected higher up. These stem lesions have a water-soaked appearance, often appearing dark purplish-brown. With time, the stem lesions may girdle the branch, which will then collapse and die. In the aerial phase of this disease (which is less common in semi-arid climates such as ours), stems, foliage and fruit may become infected and exhibit dark water-soaked lesions and fluffy white mold on fruit. Fruit can also become infected where they touch the ground, a problem for pumpkins in particular.

Conditions for disease.

The inoculum that begins the disease in a new crop most commonly comes from the soil, where it can survive for extended periods. The pathogen can also be introduced into a field from surface irrigation water from rivers or ponds containing drainage from infested fields. The disease can also come in on contaminated transplants, although commercially-grown transplants are less likely to be the source. This pathogen can be moved from infested to clean fields via soil that adheres to equipment. This disease is favored by warm, wet conditions. Infection below ground can occur when soils are saturated for as little as 5 to 6 hours. Heavy soils and compaction can result in severe disease. Optimum temperatures for infection are 75 to 92 °F. Disease due to P. capsici has been shown to be aggravated by salinity problems. Some fields with P. capsici problems last year also had salinity issues, but some did not. None the less, the salinity-P. capsici connection may have been a contributing factor to last year's epidemic, at least at some locations.

Management.

Because this pathogen can survive so well in soil, crop rotation is of limited utility. However, staying out of cucurbits, peppers, and tomatoes for three years may have some benefit. When moving equipment from infested fields, clean them of soil, if feasible. Choose well-drained fields for susceptible crops and avoid saturating the soil. In heavy soils, root and crown rot may be reduced by irrigating every other furrow and then switching furrows for the next irrigation. Carefully managed drip irrigation may also reduce disease incidence. Fungicides are not typically used against this disease under our conditions, but may be useful in some situations where there is a history of the disease. This year I'll be conducting a field trial to evaluate chemical control of this disease in peppers. I'll keep you posted of the results.

Recent Progress on White Rot Control of Garlic and Onions

Joe Nunez, UCCE-Kern
Mike Davis, UC Davis

California is by far the largest producer of garlic with over 84% of the total U.S. garlic production. Typically, about 60 percent of California's annual garlic crops is dehydrated, with 20 percent to 25 percent sold fresh and the remainder used for seed. California is also a major producer of onions with 26% of the nation's production. In 2005 California planted over 47,000 acres of onions with a value of over $200 million dollars. Most of that acreage (64%) is for processing onions with a worth of about $100 million dollars.

While Gilroy proclaims itself the "Garlic Capitol of the World", in actuality less than 500 acres of garlic is grown in the area. One of the factors for the decline of garlic in that area in the 1970's was the plant disease white rot. Garlic was also a major crop for the Tulelake basin in Northern California until white rot virtually ended garlic production there. Today Fresno County's Westside is the leader in garlic production with over 17,000 acres of garlic. But white rot is an important issue for Fresno County garlic growers, too. By 2003, 71 fields in the San Joaquin Valley representing over 10,000 acres were infested with white rot, with the majority of the infested acreage being in Fresno County.

The reason why white rot is such a concern is that white rot is a fungal disease that, once established, permanently renders a field unusable for allium (garlic, onions, leeks, etc) production. There are currently no chemical or cultural controls available to control white rot other than moving on to white rot free fields. The white rot problem cannot be understated. Thousands of acres have been rendered useless to garlic and onion growers, affecting both seed and bulb production efforts in California. Without the development of measures to control white rot, the future of garlic and onion production in California cannot be considered promising.

Caused by the soilborne fungus *Sclerotium cepivorum*, white rot is a worldwide threat to allium production. The disease is extremely serious on these crops - an inoculum density of a single sclerotium in a liter of field soil can potentially result in crop failure and no economical control measures currently exist. As a result, attempts to manage the disease have focused on reducing the populations of sclerotia in the soil.

Recent collaborative work by UC Cooperative Extension researchers has revealed ways to effectively manage this disease. Previous research showed that sclerotia stimulants can mimic the presence of an allium plant in the field. These stimulants cause sclerotia to germinate and expend energy reserves and finally die because there is no actual plant present to infect. Stimulants can be the synthetic DADS (diallyl disulfide), garlic powder, or garlic oil. However, the sclerotia stimulants can reduce sclerotia populations down by as much as 95%, but even that is not enough to prevent economic loss.

Recent research has shown that a seed treatment or in-furrow application of fungicides fludioxonil or tebuconazole will significantly protect the plants from infection all season long for both onion and garlic. When combined with the use of sclerotia stimulants, these fungicides make it possible to grow allium crops in an infested fields.

After decades of battling white rot, a solution to this devastating disease may be ahead. However, growers will still need to be diligent in preventing the spread of white rot to new fields so not to require the use of stimulants and fungicides. In the meantime, the allium industry is working hard to get these new methods of control available to growers.

Evaluation of Insect Repellents and Barriers as Methods to Control Cucumber Mosaic Virus of Bell Peppers

Joe Nunez, UCCE-Kern

Bell peppers and chili peppers in Kern County have been afflicted by cucumber mosaic virus (CMV) for the past several years. Some fields have had over 50% yield reduction due to CMV. There is no pattern as to when it or how severe the infection will be. However earlier in the season that CMV appears, the more severe the yield loss will be.

CMV is a cucumovirus that is vectored by several different species of aphids, but most efficiently by *Aphis gossypii* and *Myzus persicae*, the cotton aphid and the green peach aphid respectively. It is transmitted in a non-persistent manner, meaning the aphid vector acquires the virus after only a few minutes of feeding on an infected plant and that it can transmit the virus for a few hours afterward.

Even though the plants are being treated with a systemic insecticide from the time they are young seedlings, fields are still being infected with CMV. The reason for this is most likely because once an aphid lands on a plant surface it immediately begins to probe the plant to see if it is a suitable host plant. Once this probing begins the virus is transmitted to the plant. Even if the aphid is killed by the insecticide, it is not killed quickly enough to prevent the vectoring of the virus. Although treating pepper fields with imidacloprid does reduce the buildup of aphids in field, it does not prevent viruses from being introduced to a field.

A trial was conducted in spring of 2008 with bell peppers to determine if CMV can be controlled by insect repellents, reflective mulch, and insect barriers. The insect repellents are composed of botanical oils that are commercially available. The botanical oils tested were: A) 40% citronella oil; B) 25% citronella oil, 25% clove oil, and 5% of geranium oil; C) 20% clove oil and 10% rosemary oil; D) 5% garlic oil; and E) 3% citronella oil and 0.5% garlic oil. Other treatments included a floating row cover and silver reflective mulch.

The floating cover was the lightest weight available but the weave was tight enough to prevent aphids from passing through. Reflective mulches have been shown by others to repel aphids and thus reducing plant virus infections. A second trial was conducted without the botanical oils, instead looking at only the floating row cover and reflective mulch.

The trial was evaluated for aphid counts on a weekly basis by placing yellow sticky cards just above the plant canopy. The impact of CMV was determined by harvesting the bell peppers over the course of several weeks. Aphid counts were significantly reduced by the floating row cover and silver reflective mulch as compared to the control (figures 1 and 2). The line graph for the floating row cover is difficult to see because it follows the zero line so closely. The aphid counts were not different for any of the botanical oils compared to the control. At harvest, the floating row cover and silver reflective mulch had significant yield increase over the control plots (figures 3 and 4). The botanical oils plots yielded the same as the control plots. The use of silver reflective mulch and floating row covers can reduce the incidence of CMV in peppers.

From this first year experiment it appears that keeping aphids from landing onto the pepper plants at all is the key to reducing the incidence of CMV. Although the botanical oils didn’t achieve this goal, the use of reflective mulch and the floating row cover did an excellent job of this. The floating row cover did have reduced yields in one plot compared to the control and less than the reflective in the other. It may be that the floating row cover shaded the plants too much and preventing the plants form reaching their potential. Overall the results show the yields can be significantly higher with the use of reflective mulch or floating row cover.

Figure 1. Weekly aphid counts for Trial 1.

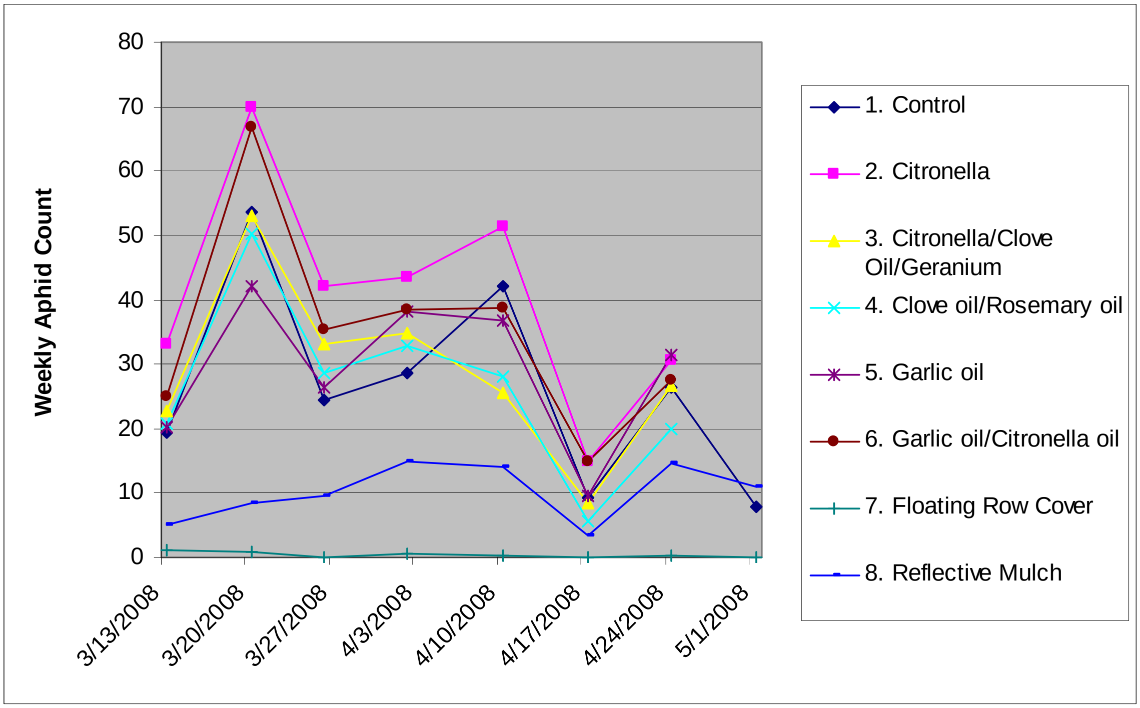


Figure 2. Weekly aphid counts for Trial 2

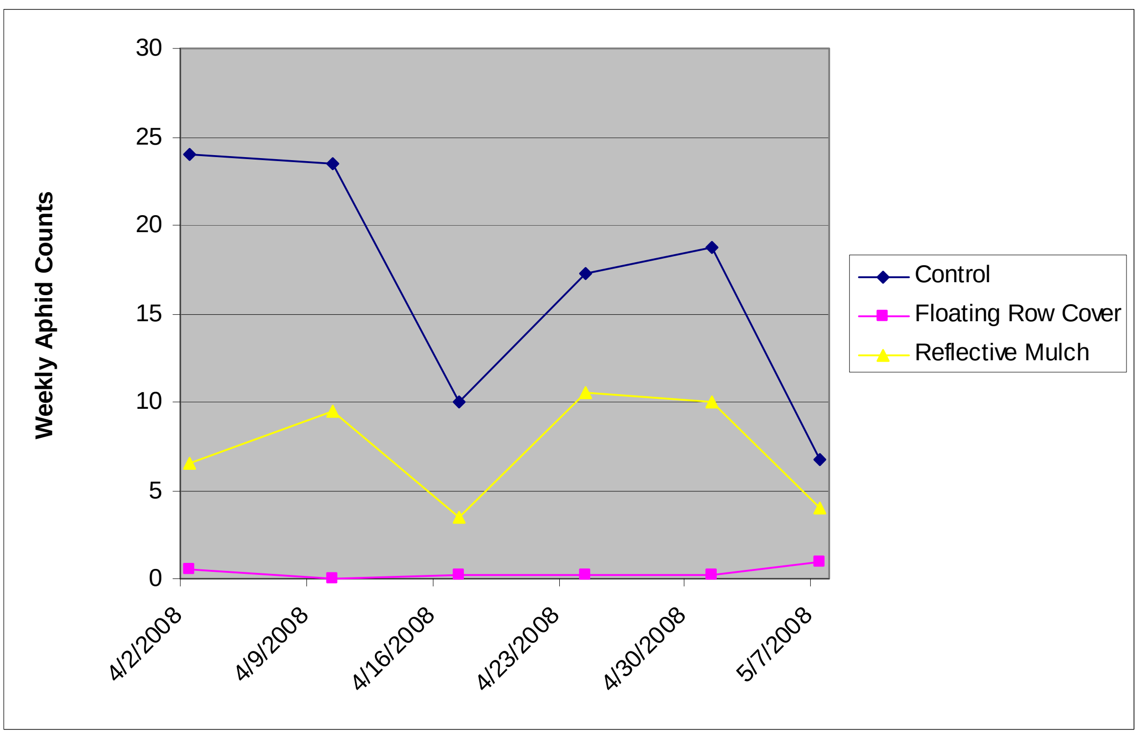


Figure 3. Yield Total for field 1

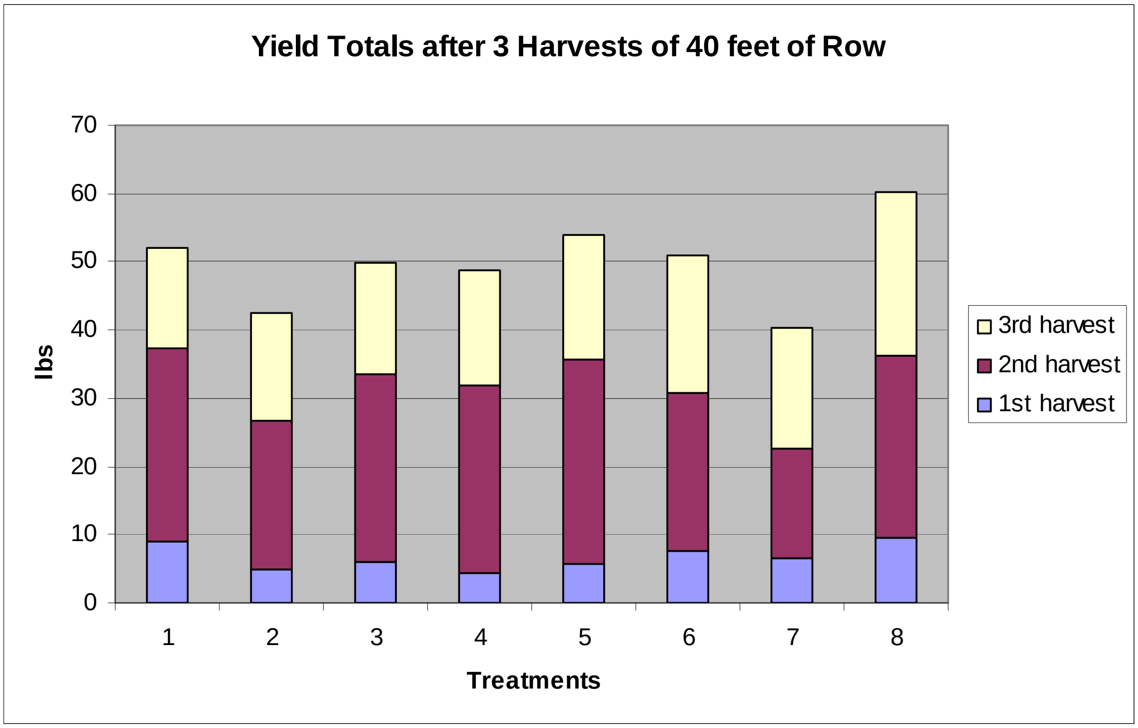
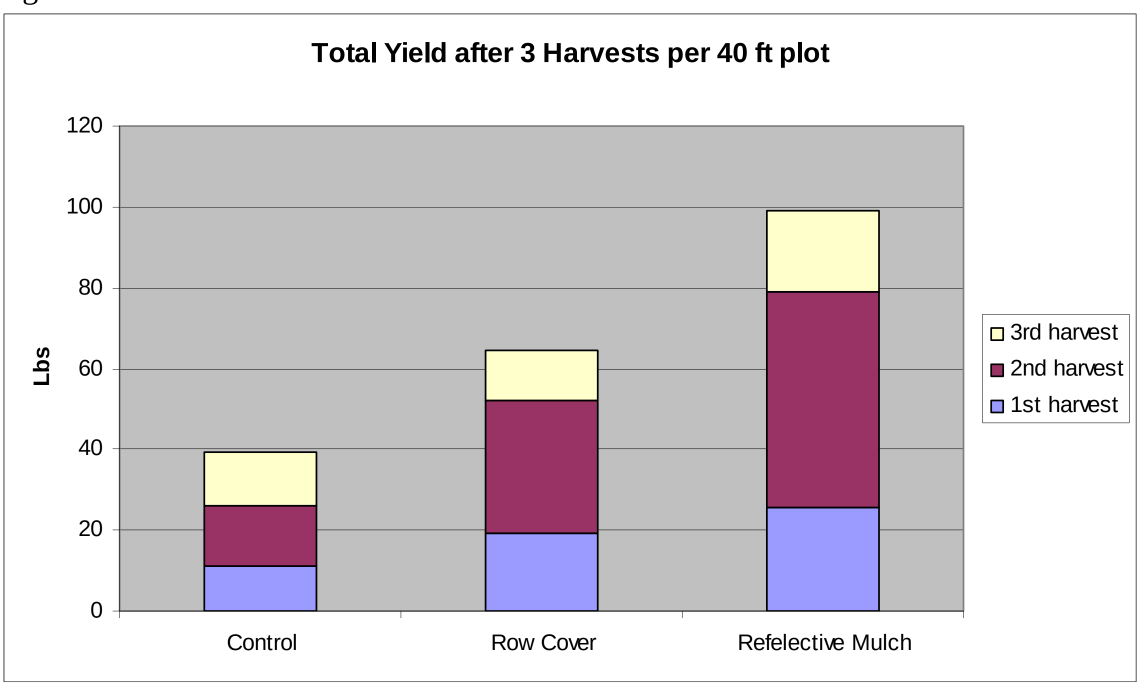


Figure 4. Yield Total for field 2



Viruses of Garlic

Mike Davis, UC Davis

Onion Yellow Dwarf probably occurs wherever onion is grown. The virus causing onion yellow dwarf also has been identified in many garlic cultivars. In onion, the disease can reduce yield and seed and bulb quality. In garlic, it is an important component of garlic mosaic.

Symptoms

The first symptoms in young onion plants are yellow streaks at the bases of the first leaves. All leaves emerging after development of the initial infection show symptoms ranging from yellow streaks to complete yellowing of leaves. Leaves are sometimes crinkled and flattened and tend to fall over. Bulbs remain firm but are undersized. Flower stalks of infected plants show extensive yellowing, twisting, and curling; flower clusters are smaller and have fewer flowers than those of healthy plants. Seed from infected plants is of poor quality. In garlic, infection causes a severe mosaic in combination with other viruses.

Causal Agent

Onion yellow dwarf is caused by the *Onion yellow dwarf virus*, a thread-like potyvirus that measures 722-820 nm long and about 16 nm in diameter. Round or slightly elongate, granular inclusions are readily seen by light microscopy in cells of OYDV-infected plants. Pinwheels, scrolls, and virus particles associated with vesicles are apparent in electron micrographs. The virus has a narrow host range, including onion, garlic, a few ornamental Alliums, and shallot, where it causes severe mosaic and stunting.

Disease Cycle and Epidemiology

The virus survives in bulbs, onion sets, and volunteer onions. It is transmissible during vegetative propagation and by the aphid *Myzus persicae* (Sulzer) and several other aphids in a non-persistent manner. It is not transmissible through seed or pollen. Losses vary according to the time of infection. Infected seedlings may form very small bulbs or fail to form bulbs at all, while plants infected during midseason may produce well-formed bulbs that are only slightly smaller than those of uninfected plants.

Management

Management measures include the production of virus-free bulbs and sets in areas free of the virus and the production of commercial crops away from infected crops or volunteers. Because the virus is limited to *Allium* species, and is transmitted by aphids in a non-persistent manner, an *Allium*-free period in a growing region can break the disease cycle. Also, the use of true seed rather than sets for onion production results in virus-free plants since OYDV is not spread by seed. Other control measures include rouging out infected plants and indexing for the virus in vegetatively propagated stock. Some onion cultivars are more tolerant than others and can be used to reduce losses. Insecticides are probably not helpful because the aphids quickly transmit the virus in a non-persistent manner as they move through the crop in search of more preferable hosts.

In garlic, virus-free planting stock produced through indexing and meristem tip culture eliminates the virus.

Garlic Mosaic

A mosaic disease of garlic was first reported in 1946 in the United States and since has been reported wherever garlic is grown. Because garlic is propagated vegetatively, many garlic cultivars are infected by one or more viruses. Before genetic-based methods to describe viruses were employed, attempts to identify the virus or viruses that cause mosaic in garlic often led to confusion because characterization of the causal agent was sometimes based on mixtures of viruses. Today, direct sequencing of partial virus genomes, or in some cases, complete genomes, has clarified the worldwide situation, but a number of synonyms for some viruses remain in the literature. In general, the label 'garlic mosaic' refers to a mosaic disease caused by a potyvirus usually in combination with one or more other viruses.

Symptoms

Primary symptoms include mild to strong mosaic, chlorotic mottling, striping, and streaking of leaves. Symptoms are usually more pronounced in young leaves. Infected plants are stunted when compared with virus-free plants grown under identical conditions and bulb size is significantly increased in crops grown from virus-free stock. Garlic is also infected by one or more latent viruses. While there may be no visual symptoms caused by the latent viruses, the effects of combinations of the many viruses found in garlic on bulb size are largely unknown.

Causal Agents

The two primary potyviruses found in garlic are *Onion yellow dwarf virus* (OYDV) and *Leek yellow stripe virus* (LYSV). Both are common but their prevalence differs among garlic-growing areas of the world. Infection by either of these potyviruses causes a severe mosaic of garlic when the plants are co-infected with other viruses. LYSV alone probably causes few, if any, symptoms on garlic. Similarly, OYDV may or may not cause symptoms by itself, but is considered one of the primary causes of garlic mosaic since infected plants are usually infected by other viruses, and their combination with OYDV may result in severe mosaic symptoms, bulb size reductions, and economic losses. Apparent synonyms in the literature for one or the other of these potyviruses include *Garlic mosaic virus*, *Garlic yellow stripe virus*, and *Garlic yellow streak virus*. The validity of these as distinct viruses is doubtful.

A number of other viruses have been reported from garlic. Generally these cause no or very mild symptoms if not present in combination with one of the potyviruses. These include the carlaviruses, *Shallot latent virus* (SLV, synonym = *Garlic latent virus* or GLV), which is common in Europe and Asia, and *Garlic common latent virus* (GCLV), which occurs in most garlic–producing areas of the world. In addition, there are many viruses in a relatively new genus of viruses, *Allexivirus*, that are particularly important in garlic because it is believed that their presence with one (or both) of the potyviruses accounts for severe mosaic symptoms. The garlic-infecting viruses in the genus *Allexivirus* include *Garlic virus X* (GVX), *Shallot virus X* (ShVX), *Garlic viruses A-D*, and *Garlic mite-borne mosaic virus* (GMbMV). The latter may be a strain of *Garlic virus C*.

Disease Cycle and Epidemiology

Because garlic is propagated exclusively by vegetative means, there is ample opportunity to maintain multiple infections and to move viruses from one geographic region to another. The primary causes of garlic mosaic, the potyviruses, are also transmitted by various non-colonizing aphids in a non-persistent manner. The carlaviruses are also transmitted by aphids in a non-persistent manner, but are less efficiently transmitted than potyviruses. Allexiviruses are transmitted by the eriophyid mite, *Aceria tulipae* Keifer, and like all garlic viruses, during vegetative propagation. Spread of Allexiviruses probably takes place during bulb storage where mites move freely among bulbs. Spread of these viruses rarely occurs in the field.

In many instances aphid vectors move potyviruses into a field too late in the growing season to cause any current season economic losses. However, cloves from infected bulbs, even if asymptomatic, cannot be used for seed in subsequent crops if optimum yields in those crops are desired. In general, the host range of *Allium*-infecting viruses is limited to *Alliums*. None of the *Allium*-infecting viruses is transmitted through true seed so most either do not occur in onion or occur rarely.

So-called 'virus-free' garlic actually may be free only of *Allium* potyviruses and possibly the carlaviruses, since the miteborne viruses are apparently more difficult to eliminate. Virus-free garlic can be produced by culturing meristem shoot tips that are less than 1 mm long, but it is difficult to maintain its virus-free status in the field because plants are quickly re-infected by insect vectors. Virus-free stock must be multiplied in areas free of commercial garlic to prevent re-infection. This 'seed' garlic is then used to plant commercial fields on an annual basis.

Management

Virus-free stocks, produced from meristem tip culture and multiplied under virus-free conditions either in isolated areas away from commercial garlic production or in insect-proof houses, can result in substantially higher yields. Bulb size and weight are increased, and virus-free bulbs contain larger cloves than do infected bulbs. Up to 50% losses have been reported in field trials comparing infected and virus-free garlic. Reduction in losses to garlic mosaic can also be accomplished to some extent by planting large cloves, even when the propagation material is virus-infected. However, it is preferable to plant virus-free cloves.

Evaluation of Plant Growth Stimulants

Joe Nunez UC Cooperative Extension-Kern

Out of scientific curiosity, I obtained some biological growth stimulant products to see if they do indeed provide a growth response. I obtained 3 products from JH Biotech, Inc (www.jhbiotech.com); 1. Promot MZM, an organic starter fertilizer but which also contained fermentation by-products of a fungal fermentation process; 2. Superzyme, a biological growth factor with various bacteria and fungi and; 3. Mycormax, a mixture of several mycorrhizae.

Previous research has shown that the addition of mycorrhizae fungi can result in a growth response on potatoes in Kern County, especially if the field has be previously fumigated. I had very little experience with other growth stimulants but have seen them work in past experiments.

The field was fumigated with metam sodium prior to planting the field to bell peppers.

At the time of transplanting, we removed several hundred plants the planting tray and dipped them into a solution of either Promot, Superzyme, or plain water. The Mycormax was a powder and we simply rubbed the root balls in the powder. The transplant crew then planted the trial under our direction in a randomized complete block design.

Within a week it could be easily seen that the Superzyme treated plants were noticeably larger and more vigorous. After 3 weeks the Superzyme and Promot treatments were larger than the control, but the Superzyme treated plants were much larger. At this time it was also noticed that the Mycormax plants were slightly stunted compared to the controls. These vigor differences remained visible until harvest.

The plants were harvested once for data. More harvests couldn’t be done because it appeared that the harvest crew had harvested before we had a chance on following harvest attempts. However we did see differences with just the first harvest.

The Superzyme plots yielded an average of 13,492 lbs per acre and the Promot yielded 11,366 lbs per acre. The control and Mycormax plots averaged 10,366 and 10,617 lbs per acre respectively (Figure 1). At an average price of $1054 per ton between 2006 and 2007, the Superzyme brought in $7,062 per acre compared to $5,481 for the control.

The results are interesting but it must be kept in mind that this is just one trial. Often times it is difficult to get repeatable data with biological products. Often times they seem to work on a particular crop in a particular field. The same trial is currently being repeated on processing tomatoes but we don’t have information on that trial as of now. But at $25-30 a gallon for Superzyme and at a use rate of 2-4 quarts an acre it is certainly a worth looking at.

Figure 1. Yield of bell peepers after one harvest.