University of California Cooperative Extension
Agriculture and Natural Resources

# Central Coast Agriculture Highlights

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## Fusarium Wilt: Soilborne Issue for Lettuce

Steven Koike, Plant Pathology Farm Advisor, UCCE, Salinas

**Introduction**

Fusarium wilt of lettuce is a damaging soilborne disease that occurs in a number of places worldwide. In California this disease was first documented in the Huron lettuce production area in 1990, and later was found in Monterey County in 2002. Lettuce Fusarium wilt is also found in the Yuma, Arizona production region. Though this disease apparently has not yet been confirmed from San Luis Obispo or Santa Barbara counties, growers and PCAs should be aware of this production threat. The disease is widespread in the Huron and Yuma areas and is a significant concern to growers. The disease is also slowly spreading in parts of southern Monterey County, indicating that the industry must be aware of long-term concerns with Fusarium wilt.

**Symptoms and diagnostic features**

Fusarium wilt can infect lettuce plants at various stages of development. The pathogen can infect seedlings and cause them to be stunted, wilt, and possibly die. Plants at the rosette or older stage can also become infected and exhibit the same symptoms along with the yellowing and eventual browning of older leaves. In all cases the vascular tissues (xylem) in crowns and taproots become reddish brown in color. The taproot may develop a hollow cavity. Plants infected at a young stage will fail to form harvestable heads. Fusarium wilt symptoms resemble those caused by ammonium toxicity and Verticillium wilt, so growers should submit samples for laboratory testing and confirmation.

**Causal agent**

Fusarium wilt of lettuce is caused by the soilborne fungus *Fusarium oxysporum* f. sp. *lactucae*. The vascular *F. oxysporum* pathogens are typically host specific. Therefore, the fungus causing Fusarium wilt of lettuce only infects lettuce (hence the designation f. sp. *lactucae*). In like manner, the Fusarium wilt pathogens of celery (f. sp. *apii*), cabbage (f. sp. *conglutinans*), tomato (f. sp. *lycopersici*), and other crops will not infect lettuce. Like all Fusarium wilt pathogens, *F. oxysporum* f. sp. *lactucae* is a soil inhabitant that can survive in the soil for long periods of time due to the production of resilient survival structures (chlamydospores).

**Disease development**

The Fusarium wilt pathogen is introduced into production fields in one of two ways. First, the pathogen is known to be seedborne, so the planting of infested lettuce seed can result in Fusarium wilt of the crop and contaminated soil in the field. Secondly, since the Fusarium chlamydospores are present in soil, infested dirt and mud adhering to equipment, tires, and vehicles can result in the fungus being introduced to previously clean fields. Movement of soil during cultivation, disking, and plowing will further distribute the pathogen within that field. The pathogen is much more damaging if soil populations are high; therefore, infested fields that have a history of lettuce plantings will experience higher percentages of diseased plants because the pathogen population can increase with each lettuce crop. Another important factor is temperature; Fusarium wilt is more severe on lettuce if ambient temperatures are warm during the production of the crop.

Figure 1. Lettuce plants can be infected by Fusarium at various stages of development, resulting in stunting and plant death.

**Management of Fusarium wilt**

1. *Avoid using infested fields for lettuce.* If possible, plant susceptible lettuce in fields that do not have the pathogen, do not have a history of the problem, or have Fusarium populations below damaging levels.

2. *Plant resistant or tolerant cultivars.* Highly resistant lettuce cultivars are not yet available. However, once such cultivars do appear on the market, growers should strongly consider using them. In the meantime, researchers and growers have found that different lettuce types have differing levels of susceptibility. In general, romaine and leaf cultivars tend to be more tolerant of Fusarium and can grow reasonably well even if infected. Crisphead (iceberg) types tend to be more susceptible. However, such traits are variable for each lettuce type, so there are some tolerant iceberg cultivars and some susceptible romaine varieties.

3. *Use healthy seeds.* Plant seed that does not have seedborne *Fusarium oxysporum* f. sp*. lactucae*.

4. *Plant lettuce during the cooler time of the season.* If one must plant lettuce in fields known to be infested, disease losses may be minimized if the crop is planted when ambient temperatures are lower rather than higher.

5. *Rotate crops.* Over-planting lettuce is a practice that maintains or increases the soil population of Fusarium. Therefore, rotate with non-host crops.

6. *Implement appropriate sanitation measures.* As much as possible, reduce the introduction and movement of infested dirt and mud into fields by washing equipment and vehicles, limiting vehicle access to fields, and other measures.

7. *Use pre-plant chemicals.* Although the application of effective pre-plant fumigants can significantly reduce soil populations of the Fusarium wilt pathogen, it is generally not cost effective to fumigate prior to planting lettuce. However, if lettuce is planted following a conventional strawberry crop, the lettuce will likely benefit from the pre-plant fumigation treatment that typically precedes strawberry. Note that fungicides applied to lettuce after planting will not be effective against *F. oxysporum* f. sp. *lactucae*.

Figure 2. An important symptom of Fusarium wilt is the distinctive vascular discoloration in crown and taproot issues.

Figure 3. If introduced to a field via contaminated soil, the Fusarium wilt pathogen can cause localized pockets of infected plants to occur.

# Evaluation of Strawberry Yield and Weed Control Following Fumigant Applications Under Totally Impermeable Film and Standard Film

**Steven Fennimore, CE Weed Specialist and Husein Ajwa, CE Specialist, UCCE, Salinas**

**Introduction**

The California strawberry industry is highly dependent on soil fumigation to control soil pests and maintain high productivity. Plastic films are used to hold fumigants in the soil at the doses needed to control soil pests and to prevent loss of fumigant. Totally impermeable film (TIF) was compared to standard film (STD) for retention of soil fumigants. Fumigants were applied by a commercial shank applicator near Salinas, CA in 2007 and applied by chemigation at Salinas in 2008.

A gas impermeable film can minimize fumigant emissions, increase fumigant retention over time, and reduce the amount of fumigant needed for effective pest control (Gamliel et al, 1998; Minuto et al, 1999; Wang et al, 1999). Benefits of impermeable films are: 1) improved retention of fumigants in soil provides more opportunity for soil degradation of fumigants rather than release into the atmosphere (Wang and Yates, 1998); 2) less fumigant may needed under impermeable film than under standard films. A relatively new barrier film is known as "Totally Impermeable Film" or TIF has been shown to apply more easily than some of the first impermeable films in years past. TIF is a five-layer film with two thin ethylene vinyl alcohol layers embedded in three layers of standard polyethylene film (Chow 2008).

Work was undertaken to evaluate impermeable film and standard film compatibility with the two major methods of application, broadcast fumigation and chemigation. The primary objective was to compare fumigant retention under TIF and STD film. Secondary objectives were to measure the effect on strawberry fruit yield and weed control.

**2007 field evaluation of TIF covering a broadcast fumigation**

A comparison of methyl bromide (MB) plus chloropicrin (Pic) retention under TIF and STD film was initiated near Salinas. MB 57% plus Pic 43% (w/w) at 350 pounds per acre, and 1, 3-D 61% plus Pic 35% w/w (trade name Telone C35) at 350 pounds per acre were applied by commercial applicator (TriCal, Hollister, CA) on October 15, 2007. As the fumigant was applied it was immediately tarped by 13 ft wide standard film (STD) or 13 ft wide TIF. Plots were 280 ft long and 33 ft wide to allow for three passes, 11 ft wide each, of the application tractor. Each treatment was replicated two times and arranged in a randomized complete block design. Fumigant concentration under the tarp was monitored with a MiniRae volatile organic compounds (VOCs) meter (Rae Systems, San Jose, CA) at 3, 27, 51, 76, 97, 120, and 166 hours after application. Fumigant samples were taken from airspace between the soil surface and the tarp at three random locations near the center of the plots. The film was cut and then removed 192 hours after application. 'Albion' strawberry was transplanted November 11, 2007 and fruit was harvested from 40 plant sample stations from April 18 to September 1, 2008. Weed control was also monitored.

**Field evaluation of TIF in 2008**

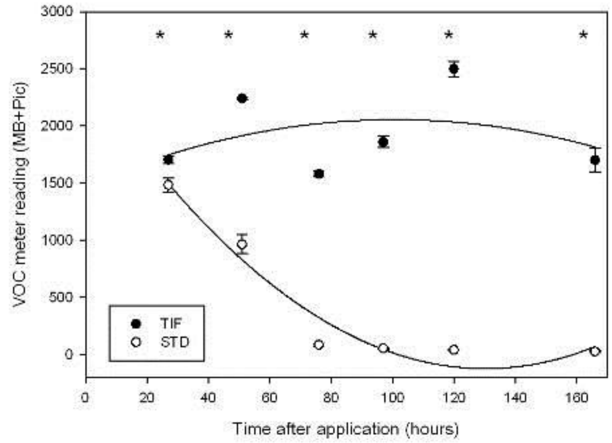
A 2008 evaluation of TIF was conducted at the USDA/ARS research farm on Spence road near Salinas, CA. Pic-Clor 60 was injected through the drip irrigation system Oct. 21, 2008 at 50, 100, 200, 300, and 400 pounds per acre under both STD (TriCal 1 mil) and TIF (Raven, Sioux Falls, SD; 1.4 mil). MB 57% plus Pic 43% (w/w) was applied on October 29, 2008 at 350 pounds per acre also through the drip irrigation system. Each treatment was replicated four times and the trial was arranged in a randomized complete block design.

Fumigant concentration under the tarp were monitored with a MiniRae VOC meter as described above at 3, 8, 24, 48, 72, 96, 144, 192, 240 and 336 hours after application. 'Albion' strawberry was transplanted by hand into all plots on November 24, 2008. Fruit were harvested from 50 plant sample stations March 30, 2009 until October 30, 2009. Nylon bags containing yellow nutsedge tubers and weed seeds (common chickweed, prostrate knotweed, little mallow, and common purslane) were buried in each plot before the fumigant application at a depth of 6 inches. Weed seeds were retrieved two weeks after the MBPic application and evaluated. Weed control was monitored.

Data were subjected to analysis of variance in SAS v. 9.1 (SAS Institute, Cary, NC) and Duncan's multiple range test was used for mean separation for all data at the 5% significance level using SAS PROC GLM. Fumigant concentration and weed density data (Salinas 2008 only) were subjected to nonlinear regression analysis using Sigma Plot v. 11 (SPSS Inc. Chicago, IL).

**Fumigant retention, strawberry fruit yields and weed control**

At the Salinas location in 2007, MB plus Pic and 1, 3-D plus Pic were both retained for 0 to 166 hours at higher concentrations under TIF than under STD (Figure 1). Strawberry fruit yields for 1, 3-D plus Pic were 348 (TIF) and 323 (STD) grams per plant, and did not differ significantly. Fruit yields for MB plus Pic were 305 (TIF) and 295 (STD) grams per plant, and did not differ significantly. Weed densities were not different between the films at the rates tested (data not shown). Because the rates tested in 2007 were at normal application rates, the rates were sufficiently high enough to suppress most pathogens and weeds regardless of the film permeability. For this reason we chose to compare fumigant retention under the two films in 2008 at a range of fumigant rates from low to high to determine if the TIF would improve retention and efficacy across a rate range.



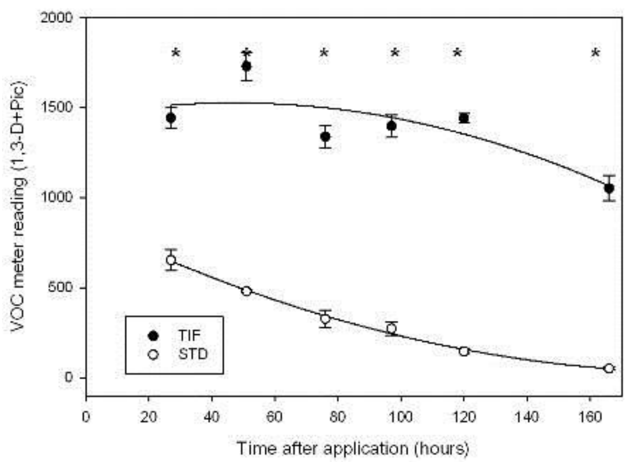




Figure 1. MB plus Pic (left) and 1,3-D plus Pic (right) meter readings at Salinas in 2007 under totally impermeable film (TIF) and standard (STD) films at 27, 51, 76, 97, 120 and 166 hours after application as measured with the MiniRae VOC meter. Plotted are the means of the treatments as open and closed circles and the lines are the predicted values of the nonlinear regression analysis. The asterisks (*) above the data indicate a significantly higher fumigant dose under the TIF than the STD. The error bars are the standard error of the mean.

## Santa Maria Strawberry Field Day

Mark your calendars for the annual strawberry field day

**When:** Friday, May 11, 2012
**Where:** Manzanita Berry Farms, 1891 West Main Street, Santa Maria.
Topics will include irrigation, salinity, nutrient management, and fumigation related issues. Stay tuned for more information.

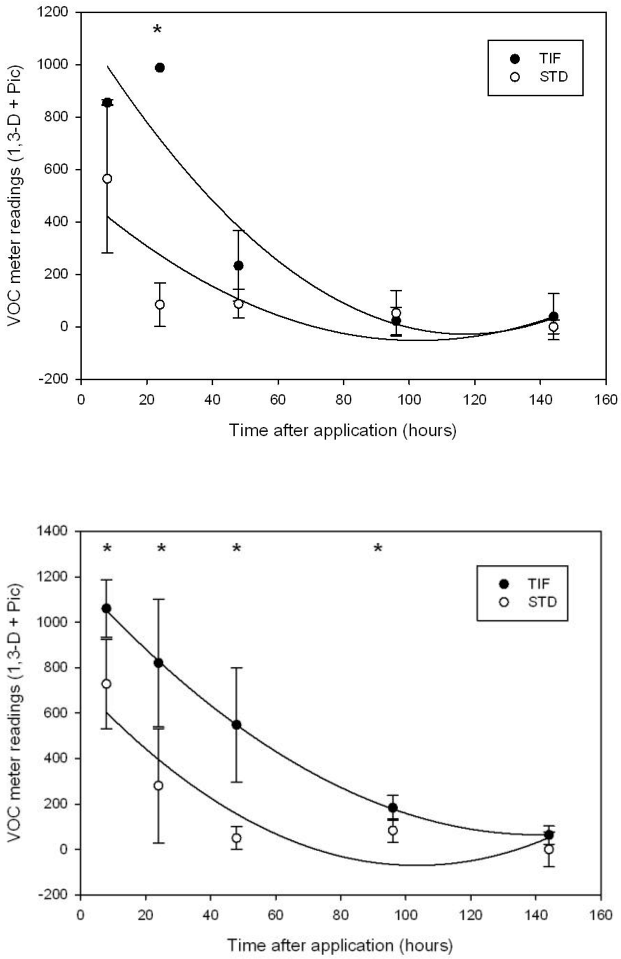



Figure 2. VOC meter reading for 1,3-D plus Pic under totally impermeable film (TIF) and standard (STD) films at 200 pounds per acre rate (left) and 300 pounds per acre (right) at 8, 24, 48, 96 and 144 hours after application at Salinas in 2008 as measured with the MiniRae VOC meter. Plotted are the means of the treatments as open and closed circles and the lines are the predicted values of the nonlinear regression analysis. The asterisks (*) above the data indicate a significantly higher fumigant dose under the TIF than the STD. The error bars are the standard error of the mean.

At Salinas in 2008, 1,3-D plus Pic concentrations in the 200 pound per acre treatment after 24 hours post application were higher under TIF than under STD film (Figure 2). The 1,3-D plus Pic concentrations in the 300 pound per acre treatment were higher under TIF than under STD film at 8, 24, 48 and 96 hours after application. No injury to strawberry was observed when transplanted 4 weeks after fumigation (data not shown). Generally there were no tarp effects on plant diameters except at the 1,3-D plus Pic rate of 100 pounds per acre where TIF plants were 9.4 inches compared to 8.3 inches for the STD plants ($P < 0.0001$). For marketable fruit yield the trend was for higher fruit yields with TIF than STD, the differences were significant in the 1,3-D plus Pic at 100 and 200 pounds per acre treatments (Figure 3). Weed densities were higher under STD film than TIF. 1,3-D plus Pic at 100 pounds per acre applied under TIF had significantly fewer weeds than 1,3-D plus Pic applied at the same rate under STD film (Figure 4). Yellow nutsedge tuber survival was less under TIF than STD at 100 pounds per acre 1, 3-D plus Pic, but not at the other rates. Common purslane and common chickweed seed survival were lower under TIF than STD film at 50 pounds per acre 1, 3-D plus Pic. Little mallow and knotweed viability were similar under both films (data not shown).

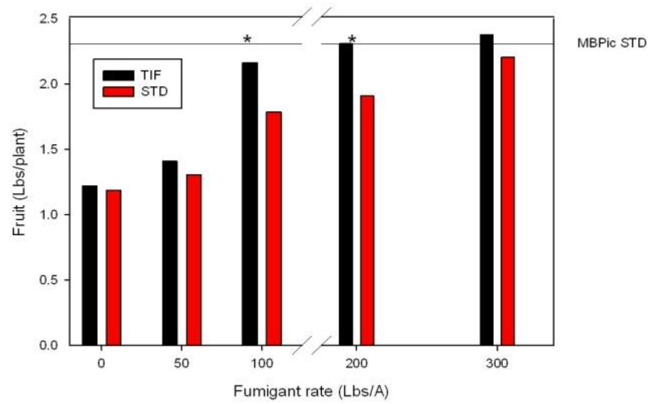



Figure 3. Strawberry fruit yield per plant from March 30 to October 30, 2009 in plots previously fumigated with 1, 3-D plus Pic using TIF or STD films. The reference standard yield is MBPic at 350 Lbs. per acre under STD film as indicated by the reference line at 2.31 Lbs of fruit per plant. By comparison the MBPic yield under TIF was 2.26 Lbs of fruit per plant which was statistically similar to STD (not shown). The asterisks above the 1,3-D plus Pic 100 and 200 Lbs per acre treatments indicates that the yield under TIF was significantly higher than under standard film.

Differences in weed control due to film type were only observed at the lower fumigant doses of 50 to 100 pounds per acre. This is likely due to the fact that TIF retained more fumigant than STD, which resulted in a higher dose and lower weed seed survival under TIF than STD (Figure 4). At fumigant application rates above 100 pounds per acre, the fumigant concentrations under both TIF and STD films were sufficiently high to kill weeds, so no differences were found between the films.

**Summary of findings**

Results presented here from two trials conducted over two years, indicate that TIF consistently held MB plus Pic and 1,3-D plus Pic (Telone C35 and Pic-Clor 60) at higher concentrations than under STD film (Figures 1 and 2). At fumigant rates of 200 pounds per acre or

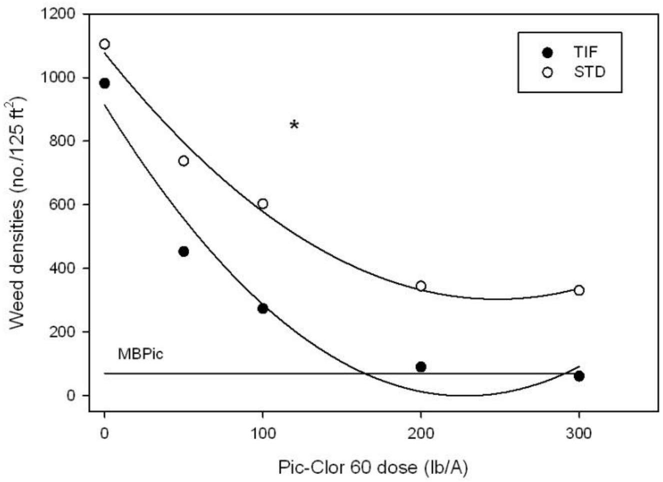



Figure 4. Season-long weed densities per 125 ft2 sample area in plots previously fumigated with 1, 3-D plus Pic using TIF or STD films. Plotted are the means of the treatments as open and closed circles and the lines are the predicted values of the nonlinear regression analysis. The reference for weed control is MBPic under standard film as indicated by the reference line at 69.3 weeds per 125 ft2. The asterisk above the 1,3-D plus Pic 100 pounds per acre treatment indicates that the weed densities with TIF were significantly lower than under standard film.

less, strawberry fruit yields were higher, and weed control was more complete where TIF was used compared to STD film (Figures 3 and 4). This is likely due to the higher fumigant concentrations under the TIF being held for a longer time than under the more permeable STD film, so that weeds and possibly soil pathogens (not measured) were more thoroughly controlled under TIF than STD. Drip applied 1,3-D plus Pic under STD film required at least 300 pounds per acre to provide fruit yields comparable to MB plus Pic (Figure 3). In contrast, 1,3-D plus Pic drip applied under TIF at 200 pounds per acre had fruit yields and weed control similar to MB plus Pic, a 33% reduction in 1,3-D plus Pic rate compared to STD film. Similarly, Ajwa et al. (2005) found that rates of drip applied Pic required to produce strawberry yields similar to MBPic, were 294 and 198 pounds per acre under STD and VIF, respectively, a 48% reduction in Pic applied under VIF.

We are grateful for the financial support of Kurray Americas and Mitsui Plastics for this project. We thank TriCal, and Raven Industries land, material and technical support, Jonathan Hunzie for making the fumigant applications and J. Ben Weber for monitoring weed densities.

**References**

Ajwa, H.A., S. Shem-Tov, S. Klose, S. Fennimore, and K. Roth. 2005. Strawberry yield and weed control with shank and drip applied Midas In: Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions. Abstract 53.

Chow, E. 2008. Properties of EVOH and TIF Films for the Reduction of Fumigant Dosage and VOC Emission. Presentation 38 at Ann. Int. Res. Conf. on MeBr Alternatives and Emission Reductions. Orlando, FL, Nov. 11-14, 2008. http://www.mbao.org/2008/Proceedings/mbrpro08.html

Gamliel, A., A. Grinstein, L. Klein, Y. Cohen, and J. Katan.1998. Permeability of plastic films to methyl bromide: field study. Crop Protection 17:241-248.

Minuto, A., G. Gilardi, M.L. Gullino, and A. Garibaldi. 1999. Reduced dosages of methyl bromide applied under gas-impermeable plastic films for controlling soilborne pathogens of vegetable crops. Crop Protection 18:365-371.

Wang, D. and S.R. Yates. 1998. Methyl bromide emission from fields partially covered with a high-density polyethylene and virtually impermeable film. Environ. Sci. Tech. 32:2515-2518.

Wang, D., S.R. Yates, J. Gan, and J.A. Knuteson. 1999. Atmospheric volatilization of methyl bromide, 1, 3-dichloropropene, and propargyl bromide through two plastic films: transfer coefficient and temperature effect. Atmospheric Environ. 33:401-407.

# Salinity in Strawberries

**Surendra Dara, Strawberry and Vegetable Crops Advisor/Affiliated IPM Advisor, San Luis Obispo**

Strawberries are among the crops that are very sensitive to salinity. Lack of rains earlier during this season has caused some concern about the impact of salinity on young strawberry plants. However, with the recent rains the total amount of precipitation in Santa Maria area for January, 2012 was about 2 inches (~50 mm) easing some of the concerns.

Symptoms of salt injury include dry and brown leaf margins, brittle leaves, stunted plant growth, dead roots and plants. When salt toxicity is seen in localized areas in a field, it could be due to poor drainage. Symptoms can be seen throughout the field when salinity of the irrigation water is high. Excessive fertilization or application to wet foliage can also result in salt toxicity. More than 0.2% of sodium or more than 0.5% of chloride in plant tissue indicate salt toxicity.


Strawberry crop injured by high salinity (above, photo by: Dr. Stuart Styles, CalPoly). Symptoms of salt injury are characterized by brown and brittle leaf margins (below, photo UC IPM)

Salinity of the irrigation water depends on the amount of sodium, calcium and magnesium salts. Salinity is measured either as *total dissolved solids* (TDS) or the *electrical conductivity* (EC) imparted by the salts. The latter is often considered a better measure of salinity and is expressed as the EC of the irrigation water ($EC_w$) or the EC of the saturated soil extract ($EC_e$). Units of measurement for are milligrams/liter (mg/L) for TDS and decisiemens/meter (dS/m) for EC. Other parameters for soil salinity are pH and the *sodium absorption ratio* (SAR). SAR is a measurement of sodium absorption compared to calcium and magnesium absorption and is used as an infiltration index.

Insufficient leaching of irrigation water in the soil is a major cause of salt accumulation in the root zone. When irrigation is made just to meet the plant needs, salts gradually build up in the root zone. It is important to provide sufficient irrigation so that water will wash the salts away from the root zone. The proportion of water that leaches below the root zone after meeting the crop needs is known as *leaching factor* (LF). The amount and frequency of irrigation should be calculated appropriately to allow sufficient leaching at the same time avoiding excessive soil moisture which could cause other problems.

Compared to the crops grown in hot and dry areas, crops grown in milder climatic areas such as California Central Coast are likely to tolerate higher salinities. Salts in the Central Coast area waters are gypsiferous with calcium and sulfate ions. Waters with such salts do not cause the same level of detrimental effects compared to water with chloride even when they have same $EC_w$.

According to Dr. Stuart Styles, Professor of BioResource and Ag Engineering at CalPoly, $EC_w$ (salinity of the irrigation water) is a better indicator than $EC_e$ (salinity of the soil) to measure the impact of salinity on strawberry or other crop yields in the Central Coast. There can be up to a 50% reduction in the yield potential of strawberries when the salinity increases from 0.7 to 1.7 $EC_w$ (dS/M) with a leaching factor of 15-20%.

It is important to look at the type of salt and kind of test being done to determine the salinity. It is also necessary to consider the leaching factor when scheduling irrigation. Sampling the irrigation water two or more times a year to test is recommended if salinity is suspected. The following are ideal properties of irrigation water for strawberries:

| Characteristic | Ideal level |
|---|---|
| Electrical conductivity ($EC_w$) | 0.7 dS/m |
| Total dissolved salts (TDS) | 450 mg/L |
| Sodium | 3 SAR |
| Chloride | 4meq/L (milliequivalent/L) |
| Boron | 0.7 mg/L |
| Nitrate | 5 mg/L |
| Bicarbonate | 1.5 meq/L |
| Acidity | 6.5-8.5 pH |

**References**


Grattan, S. R. 2002. Irrigation water salinity and crop production. UCANR publication 8066 (http://anrcatalog.ucdavis.edu/pdf/8066.pdf)

Hanson, B. R. and W. Bendixen. 2004. Drip irrigation evaluated in Santa Maria Valley strawberries. California Agriculture 58:48-53 (http://ucanr.org/repository/cao/landingpage.cfm?article=ca.v058n01p48&fulltext=yes#bib5)

Maas, E. V. and S. R. Grattan. 1999. Crop yields as affected by salinity. *In* R. W. Skaggs and J. van Schilfgaarde, eds., Agricultural Drainage. Agron. Monograph 38. ASA, CSSA, SSSA, Madison, WI.

Martínez, M. C. and C. E. Alvarez. 1997. Toxicity symptoms and tolerance of strawberry to salinity in the irrigation water. Scientia Horticulturae 71: 177-188.

2008. IPM for strawberries. UCANR publication 3351.


# Recent Brown Marmorated Stink Bug Sightings in Two Central Coast Counties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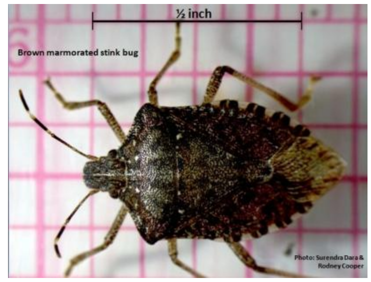


Brown marmorated stink bug (BMSB), *Halyomorpha halys* Stål is an invasive pest in the United States and is a threat to various field crops, fruit trees, ornamental plants, and many hosts. It is also a major nuisance in the urban areas where large overwintering populations accumulate in and around buildings.

Many exotic pests are inadvertently introduced to new areas through the movement of people, their belongings, and infested plant material. BMSB has been reported to spread by hitchhiking on the packaging when people are moving from the infested areas. A few months ago, BMSB were found in San Luis Obispo in an incoming shipment of household items from Pennsylvania. Very recently, it was found in Santa Barbara County in household items coming from Virginia. In both cases, local Ag Commissioners' offices immediately addressed the issue and contained the pest. However, these incidents emphasize what seems to be a common means of spread of this pest. People coming in from infested areas should be extra careful to avoid bringing in this serious pest. If you suspect BMSB in your area, contact your local UCCE or Ag Commissioner's office.

**Presentations from strawberry and vegetable crops related meetings can be found at the following link:**
http://cesantabarbara.ucdavis.edu/Strawberry_Production/Meeting_Presentations/

**Blog articles about strawberry and vegetable production and pest management issues:**
http://ucanr.org/blogs/strawberries-vegetables/

**Blog articles on other pest related topics:**
http://ucanr.org/blogs/pestnews/