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STRAWBERRY PLANT NUTRIENT SUFFICIENCY LEVELS REVISED

Mark Bolda, Tom Bottoms and Tim Hartz

It has been more than 30 years since UC published strawberry leaf nutrient diagnostic guidelines (Publication 4098, ‘Strawberry deficiency symptoms: a visual and plant analysis guide to fertilization’, released in 1980). In the years since that publication, varieties, production practices and yield expectations have changed considerably. In 2010 we began a project, funded by the California Strawberry Commission, to reevaluate leaf and petiole nutrient sufficiency ranges for day-neutral strawberries. With the cooperation of many berry growers in the Watsonville-Salinas and Santa Maria areas we collected leaf and petiole samples from more than 50 ‘Albion’ fields over the past two production seasons. In each field samples were collected 5 times over the production season, from early spring through September, to document the nutrient concentration trends from pre-fruiting to post-peak production. Leaf samples were analyzed for total concentration of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), zinc (Zn), manganese (Mn), iron (Fe) and copper (Cu). Petioles were analyzed for NO3-N, PO4-P and K concentration.

After the season cooperating growers provided yield information, which allowed us to categorize the fields as being ‘high yield’ or low yield’. We then applied a process called DRIS (Diagnosis and Recommendation Integrated System) to mathematically evaluate the difference in nutrient concentrations as well as nutrient ratios between high yield and low yield fields. This process allowed us to identify which of the high yield fields were ideally balanced nutritionally. From this group of nutritionally balanced, high yield fields we were able to calculate a DRIS sufficiency range for each nutrient at each growth stage.

Fig. 1 shows that leaf N, P and K concentrations were highest before harvest began (stage 1, which was late February in Santa Maria and late March in Watsonville-Salinas), and declined to a reasonably stable level throughout the main harvest period (stages 3-5, May-July in Santa Maria, June-August in Watsonville-Salinas). The decline in leaf macronutrient concentrations during the peak harvest period was expected; it happens in many fruiting crops because the leaves rapidly translocate nutrients to the developing fruit. By contrast, micronutrient concentrations either increased from early vegetative growth to the main harvest period (as was the case for B, Ca and Fe), or remained reasonably stable over the entire season (all other micronutrients). The vertical bars on each data point on Fig. 1 indicate the range of values typical of nutritionally balanced, high yield fields at each growth stage. These are the DRIS sufficiency ranges; leaf nutrient concentrations within these ranges can safely be assumed to be adequate for high yield production.

Table 1 lists the DRIS leaf nutrient sufficiency ranges for pre-harvest and main harvest growth stages. For the sake of comparison, both the sufficiency ranges given in UC Publication 4098 and the current University of Florida guidelines have been included. Although for most nutrients the ranges match pretty well, for others there are substantial differences. Where the DRIS sufficiency range is substantially higher than the other sources (Ca, Mn and Fe, for
example) it is because those nutrients are in such abundant supply in our coastal soils that plant uptake is far in excess of actual plant requirement; for those nutrients a lab test result marginally below the DRIS range would not be a matter of concern.

For several nutrients (N, Zn and Cu) the DRIS sufficiency range fell below the other recommendations. We are confident that the DRIS ranges represent nutrient sufficiency because they were determined by measuring the levels common in high yield fields. The field survey approach used in this project ensured that a wide range of field conditions and grower practices were included, so the results are broadly representative of the coastal industry. Also, for all three nutrients the average leaf concentrations of the high yield and low yield groups were essentially equal, suggesting that availability of these nutrients did not limit yields.

Fig. 2 shows the trends in petiole nutrient concentrations over the season. Petiole NO3-N was so highly variable as to be nearly worthless as a diagnostic technique; during peak fruit harvest (our sampling dates 3 and 4) petiole NO3-N in high yield fields varied from < 200 PPM to 2,600 PPM. While we believe that leaf total N is a more reliable measurement, this study suggests that maintaining petiole NO3-N > 1,000 PPM pre-harvest, and > 400 PPM during peak harvest, is adequate to maintain high productivity. Given the high variability of petiole NO3-N it is possible that concentrations < 400 PPM would be adequate during the summer.

Petiole PO4-P and K were less variable than petiole NO3-N. Maintaining PO4-P > 1,200 PPM throughout the season should ensure P sufficiency. Given the high soil P availability in most coastal soils rotated with vegetable crops, this level is probably much higher than the ‘critical value’. Maintaining petiole K > 2.5% preharvest, and > 1.5% during peak harvest, appears to be adequate.

Table 1. Comparison of DRIS leaf nutrient sufficiency ranges with prior UC recommendations, and current University of Florida guidelines.

<table>
<thead>
<tr>
<th>Growth stage</th>
<th>Nutrient</th>
<th>DRIS</th>
<th>UC Pub. 4098</th>
<th>University of Florida</th>
</tr>
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<tr>
<td>pre-harvest</td>
<td>% N</td>
<td>3.1 - 3.8</td>
<td>3.0 - 3.5</td>
<td>2.0 - 3.0</td>
</tr>
<tr>
<td></td>
<td>% P</td>
<td>0.50 - 0.90</td>
<td>0.20 - 0.40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% K</td>
<td>1.8 - 2.2</td>
<td>1.5 - 2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% Ca</td>
<td>0.6 - 1.3</td>
<td>0.4 - 1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% Mg</td>
<td>0.23 - 0.45</td>
<td>0.25 - 0.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% S</td>
<td>0.19 - 0.23</td>
<td>0.25 - 0.80</td>
<td></td>
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<tr>
<td></td>
<td>PPM B</td>
<td>31 - 46</td>
<td>20 - 40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PPM Zn</td>
<td>13 - 28</td>
<td>20 - 40</td>
<td></td>
</tr>
<tr>
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<td>PPM Mn</td>
<td>75 - 600</td>
<td>30 - 100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PPM Fe</td>
<td>70 - 140</td>
<td>50 - 100</td>
<td></td>
</tr>
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<td></td>
<td>PPM Cu</td>
<td>3.3 - 5.8</td>
<td>5 - 10</td>
<td></td>
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<tr>
<td>main harvest</td>
<td>% N</td>
<td>2.4 - 3.0</td>
<td>&gt; 3.0</td>
<td>2.0 - 3.0</td>
</tr>
<tr>
<td></td>
<td>% P</td>
<td>0.30 - 0.40</td>
<td>0.15 - 1.30</td>
<td>0.20 - 0.40</td>
</tr>
<tr>
<td></td>
<td>% K</td>
<td>1.3 - 1.8</td>
<td>1.0 - 6.0</td>
<td>1.1 - 2.5</td>
</tr>
<tr>
<td></td>
<td>% Ca</td>
<td>1.0 - 2.2</td>
<td>0.4 - 2.7</td>
<td>0.4 - 1.5</td>
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<tr>
<td></td>
<td>% Mg</td>
<td>0.28 - 0.42</td>
<td>0.3 - 0.7</td>
<td>0.20 - 0.40</td>
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<tr>
<td></td>
<td>% S</td>
<td>0.15 - 0.21</td>
<td>&gt; 0.10</td>
<td>0.25 - 0.80</td>
</tr>
<tr>
<td></td>
<td>PPM B</td>
<td>40 - 70</td>
<td>35 - 200</td>
<td>20 - 40</td>
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<td></td>
<td>PPM Zn</td>
<td>11 - 20</td>
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<td>20 - 40</td>
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<td></td>
<td>PPM Mn</td>
<td>65 - 320</td>
<td>30 - 700</td>
<td>25 - 100</td>
</tr>
<tr>
<td></td>
<td>PPM Fe</td>
<td>85 - 200</td>
<td>50 - 3,000</td>
<td>50 - 100</td>
</tr>
<tr>
<td></td>
<td>PPM Cu</td>
<td>2.6 - 4.9</td>
<td>3 - 30</td>
<td>5 - 10</td>
</tr>
</tbody>
</table>
NITROGEN UPTAKE BY SPINACH: RESULTS OF THE 2011 EVALUATIONS

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Richard Smith, Farm Advisor and Aaron Heinrich, Staff Research Assistant

Background
Spinach will be an at risk crop with regards to nitrogen (N) management. The crop has strict quality demand standards for deep green color which can require N applications beyond the agronomic requirements of what is needed to grow the crop. Wet spring weather can make growing a crop with the required green color difficult. It will be a challenge for growers to comply with the 1.0 N balance ratio that was set as a milestone by the Central Coast Regional Water Quality Control Board (CCRWQCB) in the Ag Order regulations passed in March 2012. The 1.0 N balance ratio refers to the quantity of N applied to the crop versus N taken up by the crop. However, there is little data on the nutrient uptake characteristics for modern, high-density spinach production as it is practiced here on the Central Coast. The focus of this study was to evaluate N uptake pattern of spinach over the course of the growth cycle. Potassium and phosphorus uptake were also evaluated at some sites.

Summary
Modern clipped spinach is grown on 80-inch beds, typically for 30 days and harvested mechanically. Overall it has a moderate demand for N. The demand for N depends on the product that is being grown; in these studies baby, teenage, and bunch spinach N uptake was 75, 96, and 115 lbs N/A, respectively. The demand for N by spinach can be high during specific periods during...
the crop cycle. In the first two weeks of growth, N uptake is low due to the small size of the crop; the average N uptake by spinach in the first two weeks of the growth cycle was 7 lbs N/A. At two weeks after planting to harvest, spinach growth and N uptake increases rapidly and averaged 4.3 lbs N/A/d. However, in the week preceding harvest, average N uptake averaged 7.3 lbs N/A/d, but was measured as high as 10 lbs N/A/d. In comparison, lettuce N uptake from thinning to harvest ranges from 3.7-4.4, but can be as high as 5 lbs N/A/d. The high-density planting on 80-inch wide beds and high N content at harvest (5.5%) explain the high N uptake rates for spinach. The amount of N in crop residue left in the fields after harvest were 44% and 35% of total biomass N for clipped and bunch spinach, respectively. Spinach has a higher demand for potassium (K) than N, with an average K uptake total K uptake averaging 129 lbs K/A and daily uptake of 7.9 lbs K/A/d from two weeks after planting to harvest. Phosphorus (P) uptake was 10 lbs P/A which is equivalent to P taken up by mature lettuce.

**Methods**

Nitrogen uptake at 15 commercial field sites in the Salinas and San Juan Valleys was evaluated in 2011. Twelve sites were mechanically harvested for fresh market clipped products and three sites hand harvested for bunch. See Table 1 for a description of each site. The spinach was planted in 18-24 seedlines per 80” bed at a density of 2-3 million viable seeds/A. We collected biomass samples 1-5 times during the cropping cycle from each site to get a measure of the N uptake pattern over the cropping cycle. Samples were collected from an area 3 feet of the bed by the width of the bedtop (5 feet); 3 to 4 replicate samples were collected on each sampling date. Plant samples were cut at ground level with lettuce knives and included the entire plant (including crown and cotyledons). This method typically left 0.25 inch of tap root on the plant samples. Depending on soil conditions, the spinach was washed to remove soil particles prior to weighing and drying. To evaluate spinach residue left in the field following mechanical or hand harvest, we collected the residue left behind using the same area and methods described above.

Measurements of soil mineral nitrogen in the top 12 inches were taken on the same day that the biomass samples were collected. The soil was extracted with a 2M KCl solution and the solution was analyzed by UC Davis’ Analytical Laboratory (Davis, CA) for nitrate and ammonium. Dried plant samples were ground using a Willey Mill to pass a 40 mesh screen (420 micrometer) and the samples were sent to UC Davis’ Analytical Laboratory (Davis, CA) for total N analysis by combustion. Select samples were also analyzed for P and K. All fields were sprinkler irrigated throughout the growing cycle.

**Results and Discussion**

*Nutrient uptake*

Nitrogen, potassium, and phosphorus uptake in fields planted from March to September (6.5 month period) are shown in Figure 1. The fields represent a wide variety of soil and climatic conditions. In the first 2 wks of growth, spinach has a low N demand, taking up an average of 7 lbs N/A. However, the two weeks prior to harvest, the N demand of N is high, with the crop taking up an average of 4.3 lbs N/A/d until harvest (Fig. 1). But, this average uptake rate underestimates N uptake in the week preceding harvest when the N mean uptake rate is 7.3 lbs N/A/d and ranged up to as high as 10 lbs N/A/d in several fields. In comparison, maximum N uptake for lettuce is in the range of 3.7-4.4 and occasionally reaches 5 lbs N/A/d. The high planting density on 80-inch beds and high tissue N content (Table 1) explain spinach's high N demand.

At harvest, N uptake for baby, teenage, and bunch spinach was 75, 96, and 115 lbs N/A, respectively (Table 1 and Fig. 2). The N uptake for bunch spinach given here may be low. Bunch fields were usually sampled on the first day of harvest. However, bunch harvest may occur over a period of a week depending on the size of the field and harvest crew, and market demand. With N uptake of 7 lbs N/A/d, a few days of growth would significantly increase N uptake by the crop. At harvest, 44% and 35% of total biomass N for clipped and bunch harvest, average N uptake averaged 7.3 lbs N/A/d, but was measured as high as 10 lbs N/A/d.
spinach, respectively, remains in the field (Table 1).

Although K uptake mirrored N uptake, with little uptake occurring in the first week of the cropping cycle, spinach's demand for K was greater than N (Fig. 1). The average K uptake was 129 lbs K/A and 7.9 lbs K/A/day from two weeks after planting to harvest, which was nearly double the N uptake rate. The rate of P uptake was 0.6 lbs P/A/day from day 13 until harvest (Fig. 1). At harvest the crop had taken up ~10 lbs P/A, which is slightly less than what a lettuce crop removes in 60-65 days.

**Fertilizer usage**
Grower applied preplant/at planting fertilizer applications averaged 66 lbs N/A, with 1st cropped fields receiving slightly more (Table 1 and Figure 3). The average date for the first post-germination N application was 16 days after germination water (DAGW). The growers did a good job synchronizing their fertilizer application with the increase in spinach N uptake that occurred around 14 days after germination (Fig. 1). Based on our results from replicated fertilizer trials (results not shown here), growers could account for residual soil nitrate in the soil and reduce preplant and at-planting fertilizer applications for 2nd and 3rd cropped spinach fields. In some situations, the residual nitrate remaining after harvest as well as crop residue N mineralization from prior vegetable crops could provide the subsequent spinach crop with sufficient nitrogen for optimal growth during the first two weeks when crop N demand is low. In some cases, this residual nitrogen would allow for a significant reduction of mid-season fertilizer applications. The use of the nitrate quick test can provide an opportunity to provide timely information on the levels of residual soil nitrate in the soil to guide fertilizer decisions (see blog entry: http://ucanr.org/blogs/blogcore/postdetail.cfm?postnum=4406). However, in the spring of 2011, the wet conditions persisted until late in the growth cycle created challenging conditions for efficient N management of spinach.

**Post harvest residual N considerations**
At harvest, 44% and 35% of total biomass N for clipped and bunch spinach, respectively, remains in the field at harvest (Table 1) which was equivalent to approximately 40 lbs N/A from both types of spinach. Spinach residue has a high percent of N and would rapidly decompose and mineralize to nitrate in warm, moist soil. The levels of residual N from fertilizers and crop residues could serve as a source of residual soil nitrate for subsequent vegetable crops.

Table 1. Details on spinach type, days to harvest, yield, nitrogen, phosphorus and potassium content at harvest and N in unharvested product and soil at harvest.

<table>
<thead>
<tr>
<th>Site</th>
<th>Product</th>
<th>Harvest DAGW</th>
<th>Fresh Biomass</th>
<th>Dry Biomass</th>
<th>Tissue N % N</th>
<th>N uptake</th>
<th>P uptake</th>
<th>K uptake</th>
<th>Residue N % of total</th>
<th>Mineral N ppm</th>
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<tbody>
<tr>
<td>1</td>
<td>baby</td>
<td>44</td>
<td>9.9</td>
<td>2.004</td>
<td>4.5</td>
<td>94</td>
<td>NA</td>
<td>NA</td>
<td>52</td>
<td>7</td>
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<tr>
<td>2</td>
<td>baby</td>
<td>29</td>
<td>11.9</td>
<td>1.689</td>
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<td>85</td>
<td>NA</td>
<td>NA</td>
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<td>3</td>
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<td>NA</td>
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<td>7</td>
<td>124</td>
<td>NA</td>
<td>62</td>
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</table>

1 – Days after first germination water; 2 – Total above ground biomass (not harvestable product); 3 – Percent of N that remains in the unharvested residue left by the harvester; 4 – Concentration of nitrate-N and ammonium-N in the soil at harvest.
Figure 1. NPK uptake in above ground biomass. Each point represents an average of 3-4 replicates. Data for P and K is incomplete at this time.

Figure 2. Nitrogen uptake by product at harvest. Error bars represent the SEM (n=5 for baby, n=7 for teenage, and n=3 for bunch).
Long term concerns: With increasing acreage planted to strawberry and changes in disease management tools available to the industry, strawberry growers in California continue to face challenges from fungal plant pathogens that reside in the soil. Verticillium wilt and Phytophthora crown and root rot are well known problems that have been present in California for many years. Charcoal rot and Fusarium wilt are relatively new to the state and double the number of significant soilborne issues that are found in coastal California. This review summarizes these important disease concerns.

Verticillium wilt: Verticillium wilt is a well-known disease of strawberry. Early symptoms consist of stunting, delayed development, and the yellowing of lower leaves. As disease progresses the older leaves wilt, dry up, and become brown; typically the younger, central leaves of the plant remain green until the plant dies and all foliage turns brown. In contrast to Verticillium wilt of other crops such as lettuce, vascular discoloration in strawberry crowns may be subtle or absent. Disease symptoms can be accentuated if the infected plant is subject to stress such as from environmental extremes.

The pathogen, *Verticillium dahliae*, survives in the soil for long periods by producing resilient structures called microsclerotia. This pathogen is known to infect many different crop hosts. However, researchers have found that not all isolates of *V. dahliae* are the same. It has been documented that both strawberry and lettuce are infected by the same *V. dahliae* strain; crop rotations that include both of these crops, therefore, need to be carefully considered if the pathogen is present.

Phytophthora crown and root rot: Early symptoms include stunting, delayed development, and the wilting of all of the plant’s foliage. Wilted leaves may recover slightly during the
night. As disease progresses all leaves will permanently wilt, dry up, and become brown and the affected plant will die. Examination of the internal crown tissue will reveal a dark brown discoloration. Diseased roots will be completely brown and rotted.

Phytophthora crown and root rot is caused by the Oomycete organism *Phytophthora cactorum*. This soilborne pathogen can survive in the soil for a long time in the absence of a plant host. Wet, saturated soil conditions favor survival, development, and dispersal of this pathogen. Under cool wet soil conditions the pathogen produces swimming spores (zoospores) that move in soil water and infect the roots of the strawberry. For these reasons, strawberry plants that are over watered or subject to flooding and excess soil water will be particularly susceptible to this pathogen.

**Charcoal rot**: Infected strawberry plants will first exhibit poor growth, stunting, and initial dieback of older leaves. As disease progresses, only the central youngest leaves will remain green. The plants will eventually collapse and die. Examination of the internal crown tissue will reveal an orange brown discoloration. This disease also causes roots to be completely brown and rotted. If infected plants are subjected to stress, the disease progresses rapidly and symptoms are more severe. Such stress factors include environmental extremes (hot weather), under irrigation, pests (such as mites), and physiological stress from heavy fruit loads.

Charcoal rot is caused by the soil fungus *Macrophomina phaseolina*. This pathogen survives in the soil for long periods by producing resilient structures called sclerotia. *Macrophomina* is known to infect a wide range of crops; in central coast California, however, *Macrophomina* has not yet been observed on crops planted in rotation with strawberry. The development of charcoal rot has been associated with changes in the practices of pre-plant soil fumigation and has been confirmed in a number of counties where strawberry is grown. This disease presently affects only a small percentage of the total state strawberry crop. However, the pathogen appears to be spreading.

**Fusarium wilt**: Infected strawberry plants will first exhibit poor growth, stunting, and initial dieback of older leaves. As disease progresses, only the central youngest leaves will remain green. The plants will eventually collapse and die. Examination of the internal crown tissue will reveal an orange brown discoloration. If infected plants are subjected to stress, the disease progresses rapidly and symptoms are more severe. Such stress factors include environmental extremes (hot weather), under irrigation, pests (such as mites), and physiological stress from heavy fruit loads.

Fusarium wilt is caused by the soil fungus *Fusarium oxysporum f. sp. fragariae*. This pathogen survives in the soil for long periods by producing resilient structures called chlamydospores. This pathogen is host specific to strawberry and can only infect this crop. The development of Fusarium wilt has also been associated with changes in the practices of pre-plant soil fumigation but has thus far only been confirmed in southern California. However, the pathogen appears to be spreading.

**Diagnostic challenge**: Diagnosing and distinguishing between these four soilborne diseases can be problematic. *Verticillium, Macrophomina, and Fusarium* all cause poor growth, stunting, initial dieback of older leaves, plant collapse, and eventual plant death. *Phytophthora, Macrophomina, and Fusarium* all cause discolored inner crowns. There are only a few differences in symptoms; Verticillium wilt does not cause discolored strawberry crowns and Phytophthora crown and root rot causes both young and old strawberry leaves to wilt and collapse early in disease development. This overlap of symptoms means that growers and field personnel should have plants tested by a pathology lab in order to confirm which soilborne disease they are encountering.

**Management**: To battle soilborne pathogens, strawberry growers have some options. If possible, plant strawberries in fields having
no history of these problems. Alternatively, if fields are known to harbor these pathogens, then rotation to a non-host crop is advisable. These pathogens likely persist in strawberry crown tissue; therefore, once a strawberry crop is finished, enhancing the breakdown of strawberry crown tissue may help reduce soilborne inoculum. Some resistant cultivars exist for Verticillium wilt and some tolerant ones were identified for charcoal rot and Fusarium wilt. However, completely resistant cultivars are still needed. Reduce stress to the plants, as stress causes most of these diseases to be more severe. For Phytophthora crown and root rot, carefully manage irrigation and avoid overwatering. Very critically, cultivation practices and movement of farm equipment should avoid the spread of contaminated soil because all these pathogens reside in the soil; transport of infested dirt and mud on equipment will spread the fungi to new fields. Finally, obtain assistance from local extension personnel regarding disease diagnosis; samples submitted to county farm advisors can be tested for all of these soilborne pathogens.

Future of fumigation: Pre-plant soil fumigation is effective against these soilborne pathogens. However, the changes regarding available products and application rates may limit fumigation effectiveness. Tarpped flat fumigation (broadcast) with standard rates of methyl bromide + chloropicrin are generally very effective against these pathogens. Bed fumigation and drip applied fumigants with alternative products are less effective than flat fumigation because only 60 to 75% of the field area is treated and the untreated soil can still be infested with the pathogens. The loss of methyl iodide as a treatment choice for flat fumigation further reduces the available tools that growers can use to battle soilborne pathogens. Research is in progress to further understand the biology and dynamics of these diseases, develop improved resistance in strawberry cultivars, and explore other possible fumigant options. This cooperative research effort involves county-based UC extension personnel, campus-based UC researchers, strawberry growers and industry organizations (primarily the California Strawberry Commission), pest control advisors, and other members of the agricultural community.

Figure 1. Verticillium wilt.

Figure 2. Phytophthora crown and root rot.
Figure 3. Charcoal rot.

Figure 4. Fusarium wilt.
WESTERN FOOD SAFETY SUMMIT
MAY 10 & 11, 2012
HARTNELL COLLEGE
MAIN CAMPUS, STEINBECK HALL
411 CENTRAL AVE.
SALINAS, CA 93901

Thursday, May 10, 2012

- Welcome and Overview of Summit
  Dr. Phoebe Helm, Superintendent/President, Hartnell College
  Andrew Fernandez, VP of Raw Product, Taylor Farms
  Neil Ledford, Consultant, Hartnell College
- Recap - Audit Findings for 2011
  Mike Villaneva, Technical Director, LGMA - California Leafy Green Products Handler Marketing Agreement
- Equipment Design & Sanitation
  Peter DeGroot, Engineer, Valley Fabrication
- Clean in Place
  Alan Heinzen, Sales Engineer, Heinzen Manufacturing International
- Field Containers
  Mike Hutchins, Owner, Denham Plastics
- Microbiology
  Steve Koike, Plant Pathology Farm Advisor, University of California Cooperative Extension
- Soil Amendments and Composting
  Johnny Massa, General Manager, Comgro Soil Amendments, Inc.
- FDA Fresh Produce Standards Updates
  James Gorny, Ph.D, Senior Advisor for Produce Safety, Food and Drug Administration - INVITED
  Barry Eisenberg, Ph.D, Vice President, Food Safety Services, United Fresh Produce Association
- FDA Foreign Supplier Verification Program
  Janet McDonald, Ph.D, Senior Public Affairs Specialist, Food and Drug Administration - INVITED
- GFSI Certification
  Diane Dulmage, Training Services Account Manager, Food and Agriculture, Scientific Certification Systems (SCS)

Friday, May 11, 2012

- Welcome and Introductions
  Andrew Fernandez, VP of Raw Product, Taylor Farms
  Neil Ledford, Consultant, Hartnell College
- Recommendations to Prevent Cross Contamination During Hand Harvest
  Jennifer Cannon, Ph.D, Assistant Professor, University of Georgia
- Resources for Training
  Sergio Nieto-Montenegro, Hispanic Workforce Management
- Co-Management Challenges
  Paul Robins, Executive Director, Resource Conservation District of Monterey County
- Ag Waiver & Sustainability
  Bob Martin, General Manager, Rio Farms
  Jocelyn Gretz, Sustainable Agriculture Program Manager, Rio Farms
  Abby Taylor-Silva, VP Policy & Communications, Grower-Shipper Association of Central California
- Audit Harmonization
  Eileen Chase, West Coast Manager, NSF International
- Discussion Session
  Facilitator: Andrew Fernandez, VP, Taylor Farms
  Speakers:
  Jim Bogart, President & General Counsel, Grower-Shipper Association of Central California
  Barry Eisenberg, Ph.D, VP, United Fresh Produce Association
  James Gorny, Ph.D, Senior Advisor, Food And Drug Administration
  Mike Villaneva, Technical Director, LGMA

Who Should Attend:
- Executive Management: Growers, Shippers, Processors, Cooling Facilities, Shipping Facilities, and Suppliers
- Food Safety Directors, Supervisors and Managers
- Foremen, Crew Leader
- Recall Team
- Farm Labor Contractors
- Third-Party Auditors
**How to Register:** enroll online at [www.hartnell.edu/foundation](http://www.hartnell.edu/foundation) (scroll down and click on Give! - choose event registration) or complete the Application for Registration and return it with payment to the Hartnell College Foundation, 411 Central Ave., Salinas, CA 93901. Registration will be accepted on a first-come, first-serve basis as space permits. Walk-ins are welcome upon space availability. Pre-registration recommended as attendance is limited.

**Fees:** The registration fee is $189. Fee must accompany your registration and includes all course material, lunch and refreshments. A certificate of completion will be awarded at the conclusion of the course.

**Location:** Hartnell College, Main Campus, Steinbeck Hall, 411 Central Ave., Salinas, CA 93901

**Schedule:** Check-in and registration is from 7:45 to 8:00 a.m. Summit begins at 8:00 a.m. and ends at 5:00 p.m. Parking is free on the day of the event.

**Questions:** Contact Cristina Westfall at (831) 755-6810 or email cwestfall@hartnell.edu

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**Western Food Safety Summit**
May 10 & 11, 2012

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**Poster Session**
Facilitator: Laura Mills, Consultant, LGM Consulting
Elaine Berry, Ph.D, Research Microbiologist, USDA-ARS/U.S. Meat Animal Research Center, Nebraska
Michael Cahn, Ph.D. Water Resources and Irrigation Advisor, University of California Cooperative Extension, California
Jennifer Cannon, Ph.D., Assistant Professor, Center for Food Safety, Dept. Food Science & Technology, University of Georgia
Michele Jay-Russell, DVM, MPVW, Ph.D, Dipl. ACVPM, Program Manager, Western Center for Food Safety, University of California

Xiuping Jiang, Ph.D, Assistant Professor, Clemson University, South Carolina
Steve Koike, Plant Pathologist Farm Advisor, University of California Cooperative Extension, California
Patricia Millner, Ph.D, Research Microbiologist, USDA, ARS, ANRI, SASL/FSL, Maryland - INVITED
Richard Smith, Farm Advisor, University of California Cooperative Extension, California
Dr. Trevor Suslow, Extension Research Specialist, University of California, Davis, California

* Guest speakers and presenters were invited to present at the summit and several speakers are members of the Food Safety Advisory Committee at Hartnell College