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Inside

Managing El Niño Storm Runoff 1

Impacts of El Niño in 2016 .. 6

Science to The Grower: Who is lighting whom? 9

Get Cultured: Fertilizer and media management during El Niño 10

Disease Focus: The rise of Bot canker diseases 14

Regional Report: Santa Cruz/Monterey Potential impact of El Niño on Phytophthora diseases ... 17

Regional Report: Ventura Wind and rain, the grower's bain 20

Campus News: Mike Parrella leaving UC Davis 21

CDFA Nursery Advisory Report 22

New Publications 23

Managing El Niño Storm Runoff

***by* Julie P. Newman, Don Merhaut, Darren Haver, John N. Kabashima and Ben Faber**

California nursery growers need to prepare for El Niño storms that could potentially produce heavy runoff flows, flooding and mudslides. Each nursery should have a plan on how this excess runoff will be mitigated. This is important not only to prevent property loss, but also to limit the movement of sediment, pesticides, fertilizers and other contaminants into surface and ground waters. A summary of common mitigation methods are provided in this article.

Reduce Pesticide and Fertilizer Loads

Limit the amount of pesticides and fertilizers carried in stormwater runoff by implementing BMPs that reduce the use of these agrichemicals; handle and store pesticides and fertilizers in a manner that minimizes their loss to the environment. Newman and others (2008) provide a list of these BMPs that can be used in developing a nursery water quality management plan. Practices to reduce fertilizer and pesticide loads are described in detail in the *Container Nursery Production and Business Manual* (Evans 2014, Newman and others 2014).

Editor's Note

Climatologists are predicting large storms in the coming months due to warming in the Pacific Ocean known as El Niño. These storms could cause property damage and economic losses in California greenhouse and nursery operations due to flooding, landslides and electrical outages. Stormwater runoff and erosion is also a concern due to the potential movement of sediment, pesticides, fertilizers and other contaminants into surface and ground waters. Moreover, forecasts indicate that temperatures throughout the state may remain high, which could exacerbate plant disease problems found in the nursery, especially in already drought-stressed plants. In this issue, our feature and regular column articles provide helpful tips and additional resources for growers trying to prepare for winter storms. Information on plant diseases to watch for in the coming months and management of these problems is also provided.

◆ **Julie Newman and Steve Tjosvold**

MANAGING EL NIÑO STORM RUNOFF

continued from page 1

Limit Movement of Soil Particles

Sediment (loose particles of clay, silt and sand) is the most common nonpoint source pollutant, and in excessive amounts has serious implications for the health of the aquatic environment. Moreover, many pesticides, fertilizers and other constituents of concern in runoff are adsorbed to soil particles. It is important to determine the location, amount and causes of stormwater runoff in outdoor nursery production areas and nonproduction areas (e.g., roads, hillsides). Practices to reduce soil erosion at its source and methods for trapping sediment on-site must be included in nursery water quality management plans and implemented (Haver 2004).

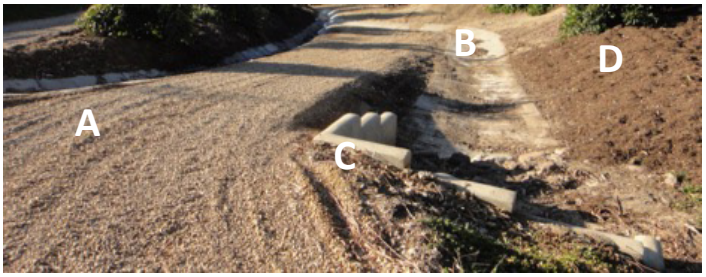

Fig. 1. Paving dirt access roads with gravel (A) reduces dust and soil loss. Concrete drainage (B) allows sediment in runoff water to settle out so that it is not carried with water downstream. Headwall (C) protects the side slopes from sloughing off into the drainage way. Mulch (D) in planted areas increases water-holding capacity in the soil, reducing irrigation frequency and runoff of nutrients and pesticides by reducing soil erosion. *Photo*: S. Webb, courtesy of the Resource Conservation District, Ventura County.

Media. Potting mix is a primary source of pesticides and nutrients found in nursery runoff so it is important to clean up spills. See Don Merhaut's "Get Cultured" in this issue for more information on media storage.

Roads. Nursery roads must be properly designed and constructed to prevent excess runoff and erosion during storm events that can pollute water supplies, increase flooding potential and trigger landslides (fig. 1–4A). Adequate road drainage from both the road surface and hill slope is important. Detailed information on the design of roads, appropriate drainage

Fig. 2. Concrete V-ditches prevent runoff water from picking up sediment and carrying it downstream. Gravel access ways increase surface area for water to impact and absorb into the soil. The gravel stays on the surface of the soil allowing for traffic in wet weather, and soil is not moved by runoff or vehicular traffic. *Photo*: S. Webb, courtesy of the Resource Conservation District, Ventura County.

structures and regulation requirements can be found in several publications listed in the references (Bender 2014, Newman and others 2014, Newman 2012).

Regrade roads to maintain proper road dimensions and slope, remove deep ruts, and repair damaged areas caused by storms only during dry weather. Avoid excessive road maintenance. Using roads during wet weather may aggravate erosion and drainage problems, particularly when roads are not protected by vegetation or gravel (fig. 1–2).

Sediment barriers. The use of sandbags, erosion control blankets, jute mesh, wattles and gravel provide a significant degree of erosion control over the absence of any mitigation method. Some sediment barriers (e.g., erosion control blankets and jute mesh (fig. 4B), made from natural or synthetic polymer fibers), can provide ground and slope stabilization, facilitating vegetation establishment. Jute materials last longer than sandbags or straw bales; they are available in assorted sizes and configurations to match all situations.

Fig. 3. Corrugated metal culvert drain pipe. Culverts provide cross drainage for roads with inside ditches. *Photo*: R. Lucas.

MANAGING EL NIÑO STORM RUNOFF

continued from page 2

Sediment pits and sediment basins. Sediment pits or traps (fig. 5) slow the movement of surface runoff and allow for the settling of large, heavy particles such as sand used in container mixes. For intercepting larger amounts of sediment, a sediment basin (fig. 6) can be constructed at the base of a nursery field. Sediment pits and basins should be designed for easy clean out, which should be done prior to winter storms. Lining with an impervious material will facilitate easier removal of collected sediment and avoid seepage into groundwater. Information on design can often be obtained from public agencies or companies specializing in water treatment, in addition to the NRCS.

Fig. 4. Controlling hillside erosion. A critical area planting (A), comprised of a mix of ornamental species planted on this roadside hill, is being used to improve slope stability; the roots anchor the soil and trap runoff, resulting in reduced sediment loads. Jute mesh (B) is being used to retain soil on the slope while plants are becoming established. The netting is biodegradable and turns into organic matter in the soil. *Photos*: S. Webb, courtesy of the Resource Conservation District, Ventura County.

Ground covers. Bare soil areas in the nursery must be protected from concentrated flows of water by covering with ground covers. Ground covers prevent the soil surface from exposure to rain or irrigation drop impact, improving infiltration. Examples of ground covers include rock, gravel (fig. 1–2), mulch (fig. 1) and plant covers. Plant covers reduce the amount and speed of runoff and can trap sediment, thereby reducing soil losses considerably compared with bare soil. Plant covers include cover crops, landscaped areas, critical planting areas (fig. 4A) and vegetated buffers (fig. 7).

Newman and others (2014) describe types of vegetated buffers and the selection of plant materials. Planting should be timed so buffers are established prior to expected storm runoff. Buffers should be inspected regularly, especially after storm events, and damaged areas immediately repaired to sustain buffer function and effectiveness. Trapped sediment changes the shape of buffers, and it may cause runoff to flow parallel to buffers rather than across them. Therefore, periodically remove sediment and reshape the buffers. Dredge ditches lined with plants before seasonal storms.

Terracing. Terracing is an effective treatment to control erosion on steep slopes (fig. 8). Some terraces are designed to collect water and temporarily store it until it can filter

Fig. 5. Shallow sediment trap used by a small nursery to remove large, heavy particles such as sand. Sediment trap shown without the cover (A) and with a grate so vehicles can drive over it (B). *Photos*: J.N. Kabashima.

MANAGING EL NIÑO STORM RUNOFF

continued from page 3

Fig. 6. A sediment basin temporarily detains sediment-laden runoff under quiescent conditions, allowing sediment to settle out. *Photo*: J.P. Newman.

into the ground or be released through a stable outlet. Other terraces are designed as a channel to slow runoff and carry it to a stable outlet such as a grass waterway.

Control Stormwater Movement

Drainage structures and drainage systems. Drainage ditches and canals should be designed to handle peak runoff flows during storms. Underdesign can lead to choke points or overflow leaving the nursery. Roadside ditches, irrigation channels (fig. 2) and

Fig. 7. Vegetated buffers are areas or strips of land maintained in permanent vegetation to prevent erosion and improve water quality. Vegetated buffers slow down runoff, thereby encouraging the settling of soil particles; plant roots take up water and dissolved pollutants from runoff water. The canna lilies in this vegetative buffer (vegetated bioswale), used in an outdoor container nursery to filter nutrients and pesticides and trap sediments, are marketed as a secondary crop. *Photo*: D. Haver.

Fig. 8. Terraces are level earthen steps that follow the contour of a hillside, breaking a long slope into shorter segments and intercepting the flow of water. Terraces serve as small dams on a hillside, intercepting runoff water and guiding it to a safe outlet. In this photo, terraces and mulch slow water that runs down the hill and also provide erosion control. *Photo*: A. Storm and J.P. Newman.

drainage structures such as culverts (fig. 3), inlets (see fig. 9) and underground outlets (conduits installed beneath the surface of the ground to collect surface water and convey it to a suitable outlet) should be inspected before and after each major runoff event; debris should be removed to restore flow capacity as needed. Clear debris and prune overgrown shrubs and brushes in natural drainage ditches that carry excess rainfall.

Control water movement in soil and container media. Practices that improve water-holding capacity and the infiltration of water into soil or container media include the use of mulches (fig. 1) and plant covers on bare soil areas in the nursery as well as the incorporation of amendments. Amendments improve soil structure so that the soil can absorb and hold more moisture,

Fig. 9. Drainage inlet surrounded by concrete berms. Water enters inlet from an adjacent asphalt road which is located at a low point on the property. Flow velocity of the water slows down prior to entering inlet, allowing sediment to drop out of the water. After entering the inlet, corrugated plastic pipes convey water underground. *Photo*: S. Webb, courtesy of the Resource Conservation District, Ventura County.

MANAGING EL NIÑO STORM RUNOFF

continued from page 4

Fig. 10. Rainwater in this nursery is collected and piped underground to a retention basin. *Photo*: D. Zurawski and J.P. Newman.

thus reducing runoff and related damage. Wetting agents may increase the water absorption of some soil textures, allowing faster wetting and reduced channeling down sides of pots. Wetting agents can also be used in field soils to improve infiltration rates where water repellency is a problem.

Conversely, in areas where groundwater contamination is a concern, percolation into the soil profile can be minimized by grading the soil (minimum 1.5% slope) so that water will flow to drainage ditches. Percolation can also be minimized by lining drainage ditches with a water-impermeable material, such as cement, plastic, or gunnite, or by installing drainage tile.

Fig. 11. This lined retention basin has rock rip-rap along the sides for stabilization. *Photo*: D. Zurawski and J.P. Newman.

Greenhouse roof runoff. Roof runoff may contain pollutants such as toxic sediments and shading compounds. Direct greenhouse roof runoff to avoid flow across areas where contaminants will be washed into the municipal storm water, sewer system, or agricultural drainage system (fig. 10).

Fig. 12. Polyacrylamide (PAM), a flocculant held in the anchored bag, removes sediment from runoff entering a retention basin. *Photo*: A. Storm and J.P. Newman.

Capture Water and Sediment

Retention basins (fig. 11), ponds and other types of impoundments can be constructed to collect large runoff flow and retain (store) runoff water. Water dissipates by infiltrating into the ground (in unlined basins) and by evaporation. Overflow may be prevented by using the collected water in recycling systems or in the irrigation of landscapes and other noncrop areas. Sediment from the collected water can be removed by settling using sediment traps (fig. 5) or sediment basins (fig. 6). Flocculants can also be used to remove sediments (fig. 12). It's important that impoundments are periodically dredged. Filtering systems should be cleaned of debris and sediment. Pumps used in recycling systems must be maintained in good working order in preparation for the rainy season. For more information on impoundments, refer to the *Container Nursery Practices and Business Management Manual* (Newman and others 2014).

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MANAGING EL NIÑO STORM RUNOFF
continued from page 5

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Impacts of El Niño in 2016

***by* Julie Newman and Steve Tjosvold**

Climatologists' predictions for 2016 indicate the potential for strong El Niño-related precipitation and flooding, particularly in southern California. Forecasts also indicate that temperatures throughout the state may remain high, complicating the precipitation picture, particularly for the agricultural sector (California Institute of Water Resources.

These predictions are based on the El Niño-Southern Oscillation (ENSO), a climate phenomenon that can provide some predictive guidance in parts of the United States under certain conditions. ENSO is characterized by year-to-year fluctuations in sea surface temperatures along the equator in the Pacific Ocean between Peru and the International Date Line, and concomitant fluctuations in sea level air pressures between Tahiti and Darwin, Australia. The ENSO cycle is expressed as three states: neutral conditions, El Niño (warm ocean phase), and La Niña (cold ocean phase) (Western Regional Climate Center 2015).

In March 2014, climatologists predicted an El Niño event when observations pointed to a developing warm sea surface temperature (SST) anomaly in the eastern tropical Pacific. The development did not

IMPACTS OF EL NIÑO IN 2016

continued from page 6

pan out into a full blown El Niño event and Water Year 2015 added another year to the ongoing California drought. Unfortunately, making seasonal forecasts of precipitation is scientifically difficult, and the accuracy of such predictions is much less than that of a seven-day weather forecast (Western Regional Climate Center 2015).

So why are we continuing to receive warnings to brace for a potentially wet winter in 2016? Why is it important for California nursery growers to implement flood prevention measures when the reality is we could end up looking at yet another year of drought? We asked Michael Anderson, State Climatologist for the California Department of Water Resources, to explain the basis of the predictions for strong El Niño-related precipitation in 2016.

According to Anderson, conditions in the eastern tropical Pacific in 2015 continued to warm, which suggested the long awaited El Niño event was finally developing. "By August 2015, forecasts were in place for a strong El Niño event to influence the northern Hemisphere winter-time circulation."

Fig. 1. The time evolution of the SST anomaly in the Niño region 3.4 in 2015. From August–December the Ocean Niño Index value was greater than 1.5.
Source: **CPC El Niño Diagnostic Discussion Slide Deck released on December 7.**

When attempting to make seasonal climate forecasts in developing these forecasts, scientists consider recurring and persistent, large-scale patterns of pressure and circulation anomalies over important regions of the globe that correlate with climate at a site of interest. The Niño 3.4 region is often used to correlate SST anomalies with precipitation and temperature anomalies in the Continental United States. From August–December the Ocean Niño Index value was greater than 1.5 in this region (fig. 1).

Resources to Help Growers Prepare for Potential Winter Storms

Two websites have been developed that contain a wealth of information on El Niño and preparing for potential flooding during winter storms.

•"**El Niño and Flooding Resources,**" UC ANR California Institute of Water Resources website http://ciwr.ucanr.edu/El_Nino_-_flooding_resources/ contains a wide range of materials related to storm preparedness. It also includes contact information and media coverage for UC experts on El Niño impacts, forecasting and models. California's academic institutions serve as a tremendous resource in offering everything from near-term manage-ment advice to farmers and ranchers as well as the innovative work being carried out by researchers.
•"**California Storm Ready**" (www.storms.ca.gov) is our state government's central web portal for information about how to prepare for potential winter storms. This includes updates of weather conditions and an overview of preparedness for winter storms on the State's Winter Readiness Fact Sheet. Also included are current news stories related to El Niño and videos with tips on how to prepare for flooding. On November 2, the Governor's Office, the Governor's Office of Emergency Services and the Natural Resources Agency conducted high level briefings with federal, state and local representatives on impacts and threats to the state from potential winter storms. Information on the website describes the extra care the state is undergoing to prepare for potential floods due to El Niño winter storms and the attendant sea level rise.

What does that mean for California? In general, during a strong El Niño with an Ocean Niño Index value greater than 1.5, California experiences a wetter than normal winter. During six strong El Niño events (1957–58, 1965–66, 1972–73, 1982–83, 1991–93 and 1997–98), California received 120 to 160 percent of normal precipitation from October through March (Pathak and Solis 2015).

"However, examination of the historical record during these six years indicates that such a relationship has been limited to the south coastal region of California," Anderson explains. Northern California could see wet, dry, or near average conditions (fig 2). Nevertheless, as the 2015 fall season played out, the El Niño event continued to strengthen with the SST anomaly passing 2°C and, in some locations in the tropical Pacific, 3°C. "Only two of the six strong events reached this level of anomaly —1983 and 1998 — which were both wet years," says Anderson. Thus Water Year 2016 could bring a wet winter for the entire state.

IMPACTS OF EL NIÑO IN 2016

continued from page 7

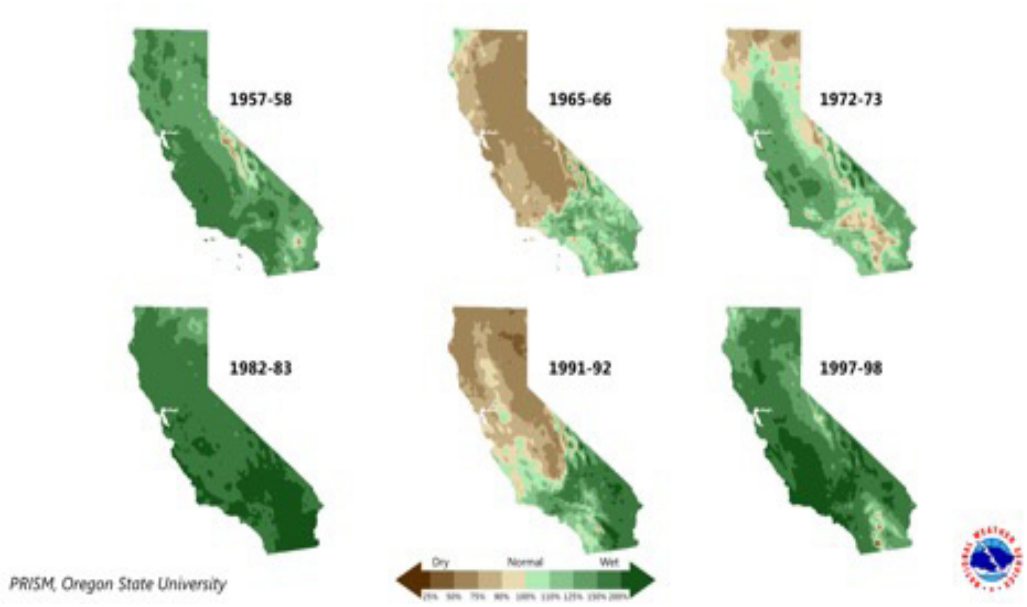

Fig. 2. Precipitation in California in six water years with El Niño events and an Ocean Niño Index value greater than 1.5.
Source: **Sacramento office of the National Weather Service.**

Anderson stipulates that the stronger signal of above average precipitation conditions likely wouldn't be seen until after the New Year, much like Water Year 1998. This prediction is based on consultations with the seasonal forecasting research community and indications from model studies. Nursery growers should be preparing now for these potential flooding conditions (fig. 3).

"So far, this water year has started slowly with accumulations trailing average. However, storms have been crossing over California with semi-regular accumulations of precipitation and snowpack. It is anticipated that this pattern will continue with accumulations improving and passing the average trajectory over the next few months. If the year plays out as expected, there is opportunity to mitigate the impacts of the ongoing drought, including improving surface reservoir storage and developing an above average snowpack to support spring and summer water use," says Anderson.

Another impact associated with El Niño events are elevated sea levels. These sea level anomalies along the California Coast are tracked by the California Nevada Applications Program (CNAP) (http://cnap.ucsd.edu/sea-level/).

"In the 20th Century, the highest annual peaks in sea level occurred during the 1983 and 1998 El Niño events. It is anticipated that the combination of the strong El Niño event and anomalously warm near-shore SSTs off California will combine with sea level rise to produce record-setting sea levels this winter," Anderson says. He points out that during the Thanksgiving king tide, new sea level records were set in locations from San Diego to Santa Barbara. "More records may be set in other locations in the coming winter months, particularly if a storm surge is involved. Stay tuned as California navigates through a potential record-setting El Niño winter in Water Year 2016."

Fig. 3. Nursery growers need to prepare now for potential flooding conditions that climatologists predict will occur in the upcoming months during winter storms. *Photo*: **D.L. Haver.**

IMPACTS OF EL NIÑO IN 2016
continued from page 8

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SCIENCE TO THE GROWER: Who is lighting whom?

***by* Richard Evans**

In the Fall 2014 issue, I wrote about a Nobel Prize that ushered in the opportunity to use light-emitting diode (LED) lamps for greenhouse lighting (see References). I'm back to write about both lighting and the Nobel Prize again — a group at Utah State University present an interesting economic analysis of greenhouse lighting that could help growers decide which light fixtures are worth investing in, and a research group in Sweden report on electronic circuits they fabricated in cut roses that make leaf cells light up like pixels in a computer screen.

The Utah State study (Nelson and Bugbee 2014) is a comparison of the efficiency and distribution pattern of seven high-pressure sodium (HPS) fixtures, ten LED fixtures, three ceramic metal halide fixtures and two fluorescent fixtures. The authors begin with three important observations. First, the desired light distribution depends on the configuration of plants and benches. Extensive, uniform blocks of plants in greenhouses with narrow aisles benefit from broad, uniform lamp output because much of the emitted light can be captured by the plant canopy. In contrast, LED fixtures may deliver more focused light in small facilities that have widely spaced benches. Their second observation is that photosynthesis and plant growth depend mainly on the quantity of visible light intercepted by leaves. Light quality (color) can affect plant shape, but has a minor effect on overall growth. Third, they note that LED fixtures usually produce no ultraviolet (UV) light, and that the absence of UV can cause disorders, such as intumescences (a topic I wrote about last Spring).

Nelson and Bugbee compared the cost of light output in three scenarios: radiation captured at all downward angles (appropriate for large, uniform blocks of plants), radiation captured within a 100° arc, and radiation captured within a 68° arc (suitable for more smaller, more focused applications of light). The operating cost of LED fixtures is at least five times more than double-ended, electronic ballast HPS fixtures in the scenario where all light is captured. When light is focused within a 68° arc, the operating cost of some LED fixtures is comparable to that of HPS fixtures. Ceramic metal halide and

SCIENCE TO THE GROWER
continued from page 9

fluorescent fixtures tend to be more expensive to operate. The authors conclude that the better HPS and LED fixtures are equally efficient, but the higher initial cost of LED fixtures results in a much higher five-year cost.

The Swedish study at Linköping University is based on work that was published by another group of scientists back in 1977 announcing the discovery of electrically-conductive polymers; three of the researchers who conducted this original work (Heeger, MacDiarmid and Shirakawa) received the Nobel Prize in Chemistry 23 years later. Earlier this year, the Swedish scientists, who continued this research, reported that a molecule taken up in a solution by cut rose stems polymerized to form an electrically-conductive polymer in the xylem (Stavrinidou and others 2015). The xylem vessels containing the polymer functioned like a conductive wire, and the "wired" stems could function as living electrical circuits. They also infused attached leaves with the polymer. Cavities in the leaves functioned like pixels, which lit up and changed color when a voltage was applied.

The creation of these electronic plants has excited scientists in the field of bioelectronics, who imagine future gardens of fruit, vegetable and flowers that function as computers. Perhaps someday greenhouse plants will light us, instead of the other way around.

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GET CULTURED:
Fertilizer and media management during El Niño

by **Don Merhaut**

During the strong El Niño event that is predicted in California for the winter of 2015–2016, there is a risk of leaching of fertilizer from containerized plants and the production areas that are exposed to the weather. Most varieties of woody ornamental plants will be dormant or growing very slowly. In fact, even many of the California native plants will have limited growth until early spring, so most plants will have minimal fertilizer needs. In this article, I will discuss methods to maintain the minimal fertility requirements of container-grown ornamentals that are located outdoors. In addition, I will provide some housekeeping items to prevent fertilizer runoff from nursery production areas. I am assuming that once the rains begin, it should be almost continuous from January through March, as this was the weather pattern, especially for Southern California, during the last El Niño in 1998.

GET CULTURED:
continued from page 10

Brief Summary of Management Practices

Fertilizer type. Use polymer-coated fertilizers rather than liquid fertilizers to provide nutrients and to minimize potential for nutrient runoff. Most, if not all, polymer-coated controlled-release fertilizers (CRFs) release nutrients as temperature increases. Even though temperatures during this El Niño winter are predicted to be warmer than usual, fertilizer release from CRFs will be minimal. Once the warmer growing season commences, nutrient release from these products will increase to meet the needs of the plants.

Fertilizer use. If your region is experiencing warm days and plant growth is still occurring on select plant species, liquid fertilization may be suitable. However, take into consideration your growing region — what part of the state you are located in. If the rainy season has begun in your area, do not add liquid fertilizer at this point; fertilizer runoff will likely occur.

Media storage. If polymer-coated CRFs have been blended into the media, during warm days, higher media temperatures could cause rapid release of nutrients from the fertilizer prills, even in storage, if the media is moist. If uncoated granular fertilizers were blended into the media, the rate of fertilizer dissolving and the potential for nutrient leaching will be even greater. This is one reason why media containing pesticides and fertilizers should be stored on a concrete pad (fig. 1). The storage area should be covered — ideally under a water-proof structure — to minimize dispersal of media by wind and rain. Tarps can also be used over pallets but keep in mind that this may increase media temperatures.

Cultural practices. If your production palette contains winter-growing species, such as many aloes, some other succulents and camellias, consider moving these plants into a hoophouse or greenhouse. Preventing rainfall on these crops will provide better control of water and fertilizer to meet the specific needs for the crop. In addition, some of these plant species are flowering during the winter, so flower and foliar diseases may be easier to control or prevent if plants are inside waterproof structures.

Fig. 1. A concrete storage pad and retaining wall are used to store and mix media with fertilizers. This reduces the movement of soil particles and fertilizers. *Photo*: **D. Zurawski and J.P. Newman.**

Irrigation collecting and recycling facilities. If irrigation runoff is collected and recycled, be prepared for excess runoff from rain events. All drainage areas ditches and gutters should be free of debris. Areas susceptible to debris flows should be inspected regularly during the rainy season.

Production beds. All production beds should be prepared so that enough slope is provided for excess water runoff. Weed cloth and gravel should be in place to prevent plants from sitting in mud. Mud and sitting water may also encourage weeds, diseases and insects. Proper bed design and construction will also minimize mud from clogging drainage channels and accumulating in collection ponds.

Record keeping. Monitoring and keeping records of nutrient concentrations in leachates and media should be part of the crop production program. By routinely monitoring parameters like electrical conductivity (EC) or total dissolved solids (TDS) media and leachate, one can get an estimate of nutrient concentrations in containers. With proper record keeping, changes in fertility and adjusting for fertilizer needs of a crop can optimize fertilizer management and mitigate nutrient loss from cropping systems.

GET CULTURED:
continued from page 11

Discussion of Fertilizer and Media Use

What follows are more detailed descriptions of fertilizer and media use and how water from rain or irrigation influences fertilize use and runoff in containers. Challenges and opportunities are also discussed.

Planting media. There are two ways nutrients from fertilizers are held in containers: absorption, and adsorption. Absorption is the physical property of the media, where the nutrients in solution are absorbed into the medium pores, much like water is held in a sponge. Organic matter such as peat moss, coir, compost and bark are good sponges and therefore provide a high water-holding capacity to media. This will allow fertilizer that is in solution to remain in the containers through the absorptive properties; however, this also means this fertilizer solution can easily leach from containers if excess water comes from irrigation or rain events. Adsorption is a chemical property, where the charged nutrients are bound to charged sites on the media, much like iron shavings are held onto a magnet. Unfortunately, the adsorptive properties of almost all artificial media are limited. There are two properties of adsorption, cation exchange capacity (CEC) and anion exchange capacity (AEC).

Cation exchange capacity (fig. 2.) describes the amount and ability of the media's negatively charged sites to bind onto positively charged ions, referred to as cations. Since most media have a low CEC, there are limited binding sites for any cationic nutrients; therefore, these nutrients easily leach from media. Positively charged nutrients include the amonium form of nitrogen (NH^{+}-N), potassium (K^{+}), calcium (Ca^{2+}) and magnesium (Mg^{2+}). The micronutrients, iron (Fe^{2+}), manganese (Mn^{2+}), copper (Cu^{2+}) and zinc (Zn^{2+}) are also cations; however, these nutrients are often supplied as chelates, which keeps the nutrients in solution.

Anion exchange capacity describes the amount and ability of the media's positively charged sites to bind onto negatively-charged ions, referred to as anions. The AEC of artificial media is almost non-existent. In fact, the AEC of many field soils is also very low. This is one of the primary reasons why nitrate-nitrogen (NO^{3-}-N), a negatively-charged compound, leaches from soils and accumulates in surface and groundwater supplies. Other plant essential nutrients with negative charges include sulfur as sulfate (SO_4^{2+}), phosphorus as phosphate ($H_2PO_4^{-}$, HPO_4^{2-}), boron as borate ($H_2BO_3^{-}$) and molybdenum as molybdate (MoO_4^{2-}).

Organic media in containers is not stable; it will slowly decompose. This is sometimes referred to as "shrinkage," and is especially evident when incompletely composted products are used as a substrate. As microorganisms and insects consume and breakdown the organic matter of dead plant tissues — compost, coir, peat, dead roots etc. — some nutrients are released and will be available for plant uptake. The amount of nutrients from this process is very limited, especially during the cooler winter months when microorganisms are not as active; however, it is a pool of nutrients that should be men-

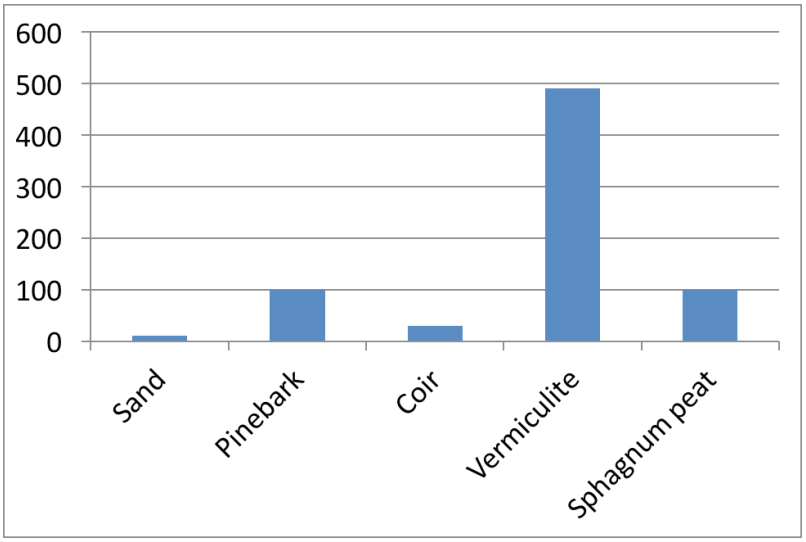

Fig. 2. Cation Exchange Capacity (CEC meq/L) of substrates. CEC is the total amount of positively charged ions that a substrate can adsorb. Not shown, the Anion Exchange Capacity (AEC) is about 1–5% of the CEC for most substrates. This is the reason anions such as nitrates and phosphates easily leach from containers.

GET CULTURED:
continued from page 12

tioned since we are discussing nutrient availability from artificial media.

Fertilizer types. There are two types of fertilizers commonly used in container production: (1) liquid fertilizers, which are dissolved in water and applied through the irrigation system, and (2) solid fertilizers, which are blended into the media or top-dressed onto containers.

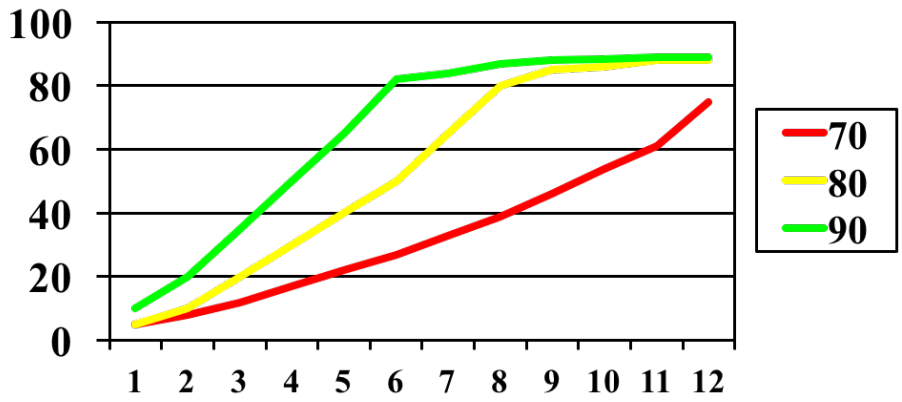

Fig. 3. Nutrient release rates from polymer-coated fertilizers. Release rate and duration of nutrient release is based on type of polymer coating and coating thickness. Graph represents fertilizer release from a 12-month release product, which has a 12-month release guarantee when media temperatures are maintained at 70°F. When media temperature increases to 80 or 90°F, rate of nutrient release increases and duration of fertilizer release from the coated prill decreases to 8 and 6 months. Refer to specific product label for product longevity and tested temperatures used for release rates.

During rainy periods, liquid fertilizers leach through containers. The majority of the dissolved nutrients will not bind to the media because the media has low CEC and AEC, as described in the previous section. Since chelates are not charged compounds, micronutrients applied in a chelated form will also easily leach from containers.

Polymer-coated controlled-release fertilizers (CRF) slowly release nutrients, despite water availability. Most of these products increase release rates as temperature increases (fig. 3). Please refer to product labels for ideal soil and media temperatures for optimal use and longevity of nutrient availability of fertilizer. Even though forecasts are predicting warmer and wetter conditions this winter, limited nutrient release from most of these products is likely to occur, unless a media temperature above the specific CRF's ideal release temperature (typically 70°F to 78°F) is sustained over a period of time. The limited release of the fertilizer during winter months will conveniently coincide with the limited needs of the plants during this period.

The release of nutrients from slow-release fertilizers are dependent on several factors, not just a single factor like media temperature, and for this reason nutrient release is less predictable than from controlled-release fertilizers. For example, sulfur-coated fertilizers slowly release nutrients based on the breakdown rate of the sulfur coating. Since breakdown of the sulfur coating can be both a chemical and biological process, nutrient release from these products may also be dictated by microbial activity, which is slower during the cooler winter months.

Non-coated granular fertilizers break down as moisture is available, the rate of which is determined by media temperature. Rate of fertilizer release is also influenced by particle size and solubility of the compounds used in the fertilizer: as temperature increases and particle size decreases, the rate of the fertilizer dissolving and nutrients being released will increase.

Manure and plant-based fertilizer products release nutrients based on nutrient solubility in the product, particle size, microbial activity and degree of decomposition of the product. Numerous types of fertilizers are available that are derived from organic materials and the nutrient release characteristics of many of these products have not been tested thoroughly. Therefore, if these products are being used, it is recommended to routinely test and keep records

GET CULTURED:
continued from page 13

of the leachate and/or media for electrical conductivity (EC) or total dissolved solids (TDS).

In closing, with proper use of fertilizers and making some modifications to cultural programs, any negative effects on fertility in containerized crops should be minimal. In fact, in areas where lower quality secondary water sources are used, the rains from this winter should help reduce salt accumulation in our production systems.

Don Merhaut is a UC Cooperative Extension Specialist for Nursery and Floriculture Crops, Department of Botany and Plant Sciences, UC Riverside.

DISEASE FOCUS: The rise of Bot canker diseases

***by* Jim Downer**

Botryosphaeria is a genus of fungi that causes diseases of woody plants commonly known in California as "Bot canker." Although these plant problems are considered canker diseases, they can also be blight-like when small twigs are involved in heavy infections. Typically Bot canker is stress related, and becomes especially damaging during periods of extreme water stress or drought (Brooks and Ferrin 1994).

Landscapes, native plant communities and orchards are alive with Botryosphaeria infections due to California's fifth year of extreme drought. Bot canker has also been an increasing problem in nurseries, as I described in my regional report in the UCNFA News Spring 2015 issue. Although the effects of drought stress in production areas are more subtle than in unirrigated nonproduction areas, irrigation water quality is deteriorating in the western United States as the drought worsens, and this saltier water imposes osmotic stress on root systems. This further predisposes woody plants in nursery production to "Bot fungi." Many news sources have indicated that El Niño will not solve our drought, and there is also evidence that drought effects on vegetation have "legacy" effects. This means that trees suffering drought in Mediterranean ecosystems, surrounding many nursery production areas, do not recover for 2 to 4 years after drought has passed (Anderegg and others 2015). Thus, we can expect Botryosphaeria inoculum to continue to plague nurseries for several years post El Niño.

Bot Biology

Botryosphaeria is in the class Ascomycetes because it produces ascospores (fig. 1) in an ascus contained in a perithecium usually found within a fruiting body or ascocarp (pseudothecium). These fruiting bodies are easily seen with a hand lens at 10x or with the

Fig. 1. Ascospores of *Botryosphaeria* causing Ficus canker disease. *Photo*: **A J Downer.**

DISEASE FOCUS:

continued from page 14

unmagnified eye. *Botryosphaeria* fungi also frequently produce asexual spores in a very similar looking structure called a pycnidium. Spore-containing structures (perithecia or pycnidia) look like small black dots and are usually found in dead tissue.

Fig. 2. Fruiting bodies of *Botryosphaeria* spp. on *Ficus microcarpa*. Fruiting bodies are only found on dead branches and may not be easily seen. *Photo*: A J Downer.

Identification of the contents of the fruiting bodies at 100x magnification assists in identification of species. Since it was not known (before the advent of modern molecular tools) what the perfect stage of pycnidium-forming fungi were, these fungi were typically given genus names in the class of asexual fungi known as Coelomycetes (imperfect fungi that form asexual spores within a fruiting body). This caused Bot fungi to have many different genus names beyond the perfect stage name (*Botryosphaeria*), such as *Fussicoccum*, *Neofussicoccum* and *Dothiorella*. Since Bot fungi seemed unique to certain hosts, many species names were described over the years for both perfect and imperfect stages of these fungi.

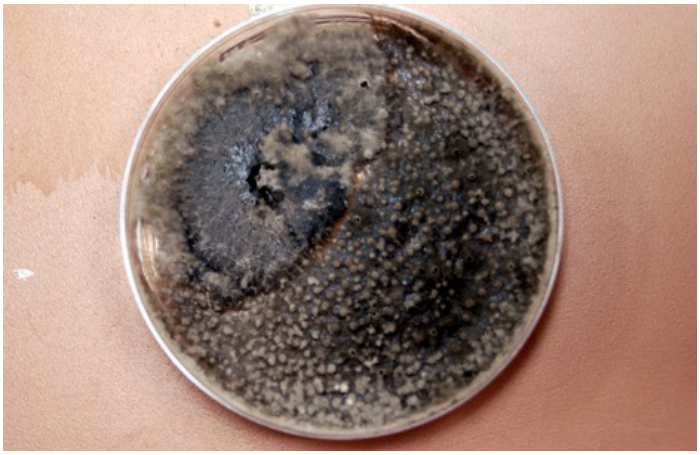

Fig. 3. *Botryosphaeria* isolates fruiting in the media with pycnidia. Note the dark color of the culture. *Photo*: A J Downer.

While many Bot species are in the literature, *B. dothidea* is perhaps the most common in landscapes, nurseries and orchards, having been recovered from over 35 hosts (Michailides and others 2000, Zhonghua and others 2001). It has a very wide host range, and can survive on an amazing array of host plants.

While *B. dothidea* is mostly asexual on plants such as pistachio, it forms both the sexual and asexual stages on commonly grown ornamental plants such as redwood.

Sometimes several *Botryosphaeria* species cause disease in a single host at the same time (Mayorquin and others 2012). Spores are splashed to new branches with rain or overhead irrigation. There is some evidence that insects and even birds may also vector spores of Bot fungi.

Symptoms and Signs

Bot fungi kill phloem tissue, eventually girdling branches and twigs. Affected nursery stock may have symptoms of leaf drop (defoliation), yellowed foliage, wilt, or increased deadwood. Dieback occurs on all ages of woody growth from young tips to entire branches and even the main stem of some woody plants. After the branch dies, sexual and asexual stages may form in dead branch tissue. However, close examination of affected branches will not often reveal the fruiting bodies, which are illustrated in fig. 2. This is because of two factors: (1) signs of Bot fungi only form on dead tissues, so symptomatic branches may just not have formed fruiting bodies yet; and (2) since fruiting bodies are small they are often covered in dirt or dust and easily overlooked.

DISEASE FOCUS:
continued from page 15

Management

Diagnosis of *Botryosphaeria* involves detection of disease symptoms and signs and may involve isolation of the pathogen on media for confirmation (fig. 3). It is helpful to wash cankered branches and twigs to make observation of fruiting bodies easier. When branches or twigs are cut from a Botryosphaeria infected plant, they often show a typically discolored xylem tissue (fig. 4). Bot fungi also stain media very dark when they are cultured on potato dextrose agar.

Fig. 4. Discolored wood of *Ficus microcarpa* infected with *Botryosphaeria* spp. *Photo*: **A J Downer.**

Nursery growers with deteriorating water quality who can implement practices to reduce salinity (e.g., blending water, using RO water, leaching), will reduce osmotic stress on root systems and the predisposition of woody plants to Bot fungi. It also becomes more imperative during drought conditions to monitor irrigations so that container stock does not dry out. Removal of cankered branches or disposal of heavily infected plants as soon as they are detected is a prudent inoculum reduction practice. For more treatment recommendations and additional photos, see the *UCNFA News Spring 2015* issue.

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REGIONAL REPORT — UC Cooperative Extension

Santa Cruz/Monterey Counties

Potential impact of El Niño on Phytophthora diseases

by **Steve Tjosvold**

El Niño conditions in the Monterey Bay area this winter are predicted to bring above average rainfall, which can come in drenching rains that flood and waterlog soils for extended periods. At the same time, winter air temperatures are predicted to be warmer than normal and consequently soil temperatures will be too. So, what impact might this have on plant diseases? At least one important group of plant pathogens might be favored by these conditions. *Phytophthora* are fungus-like pathogens that develop particularly well in wet conditions and some species, such as *P. cinnamomi*, do best in moderately warm conditions. They all need water to reproduce, spread and infect plants. During rain downpours, infested soil or spores can move readily in water runoff and splashing water. Waterlogged soil predispose nursery plants to root and root-crown infection caused by *Phytophthora cactorum*, *P. tentaculata* and other soil-borne *Phytophthora* species. The longer leaf wetness periods will favor the production of aerial spores and infection of *P. ramorum* (causing sudden oak death) and *P. infestans* (causing potato and tomato late blight), as well as other species that mostly attack and develop in aboveground portions of the plant.

Fig. 1. Aboveground symptoms of Phytophthora root rot can include wilting, yellowing and browning of foliage. Root rot symptoms of this fir tree are shown in fig 3. ***Photo*****: S. A. Tjosvold.**

Many *Phytophthora* species cause destructive crown and root rot diseases of herbaceous and woody plants in landscapes and nurseries. The leaves of plants affected by Phytophthora root or crown rot can first appear drought stressed. Leaves may turn dull green, yellow, brown, or in some cases, red or purplish (fig. 1). Plants often wilt and die rapidly with the first warm weather of the season. *Phytophthora* species can infect small and large roots, turning them brown and soft, and rendering them useless to the plant (fig. 2). Roots at the bottom of the nursery pot are frequently first infected (fig. 3). Infection of the bases of stems or root crowns is possible when transplants are planted too deeply. Often root and crown rot diseases are first noticed in the most susceptible plant species, in the most poorly drained area of the nursery, or in pots that have poor quality soil. Some *Phytophthora* species, such as *P. ramorum*, *P. infestans* and *P. nicotianae*, cause various plant blights. Although hosts of *P. ramorum* show a range of symptoms, in general the disease is characterized by irregular necrotic leaf lesions, rather than distinct leaf spots. Leaf infections can develop down the petiole and into twigs. Often, such as in camellia, infected leaves fall off before the lesion reaches the petiole. Infections may occur initially on stems or move into stems and cause blights in which stems and associated leaves wilt, become necrotic and die. A distinct dark line can mark the advance of the infection on some species.

Fig. 2. Roots infected with *Phytophthora* (right) as compared to healthy root (left). ***Photo*****: J.K. Clark.**

REGIONAL REPORT: Santa Cruz/Monterey Counties
continued from page 17

Fig. 3. Root ball of the fir tree shown in fig. 1. Often the roots at the bottom of the nursery pot are first infected. *Photo*: **S. A. Tjosvold.**

Phytophthora species can produce reproductive structures such as oospores, sporangia, chlamydospores and zoospores that are capable of infecting susceptible host tissue at their target site. Oospores are sexually-derived, heavily-walled spores that can survive for many months to years in infected roots or infested plant debris. Chlamydospores are asexual spores that are usually heavily walled and also are long-lived. Both are capable of direct infection of roots. Sporangia and zoospores can be produced from infected tissue when environmental conditions are favorable. Sporangia can directly infect host target sites, but they also produce and release zoospores capable of swimming in free water. Although these spores are ephemeral, they are capable of rapid production and dispersal, and can quickly spread the disease when water and temperature conditions are favorable.

Often the best way to identify a plant disease is to have representative plant samples sent to a plant pathology laboratory. The plant pathologist can identify the cause of the disease by finding existing spores or other tell-tale signs, or by isolating the causal organism on media. There are several field test kits that can help the field scout or farm manager to identify many common diseases, including *Phytophthora* (fig. 4). And it only takes minutes to conduct a test. These tests can sometime react to the closely related *Pythium* species and, as with any diagnostic procedure, the accuracy of the test is only as good as the plant sample taken.
See http://ucanr.edu/sites/UCNFAnews/Regional_Report_Santa_Cruz_Monterey_Cos/Spring_2015_Pathogen_field_test_kits/.

Prevention is the key to management of diseases caused by *Phytophthora*. Start with a sterile planting mix, use clean containers and keep pots up off the ground to avoid contact with existing soil. Gravel nursery beds allow for drainage away from the pots and can eliminate standing water. Don't transplant too deeply because soil covering the base of the

Fig. 4. Agdia Phytophthora ImmunoStrip. *Photo*: **UC Berkeley Forest Pathology and Mycology Laboratory.**

stem encourages infection by *Phytophthora*. Avoid irrigation practices that wet the foliage for prolonged periods. If sprinklers are used, irrigate in the morning to allow for thorough and quick drying of foliage. Prudent irrigation scheduling is important to minimize water stress, over-watering and salt accumulation in the soil. These factors can predispose plants to *Phytophthora* infection. Root media should drain well, providing at least 10% air-filled pore space after drainage. Avoid mixes that have inadequately composted components because they can break down quickly; the mix settles and loses air-filled pore space (fig. 5), in addition to potentially causing nitrogen deficiency problems.

Several fungicides help control *Phytophthora* dis-

REGIONAL REPORT: Santa Cruz/Monterey Counties
continued from page 18

Photo: **S. A. Tjosvold**

eases, but the most effective fungicide treatments are those that are specifically active on *Phytophthora* and related species. However, the regular and blanket use of these fungicides encourages the development of resistant strains. Rotation of fungicides with different modes of action is especially important to reduce the chance of resistance from occurring. A good rotation strategy should also attack different susceptible stages of the *Phytophthora* life cycle.

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Fig. 5. Root media that contain inadequately composted components break down too quickly, which compacts the media leaving less air-filled pore space. Plants in this container potting mix are more susceptible to Phytophthora root rot. *Photo*: **S. A. Tjosvold.**

REGIONAL REPORT — UC Cooperative Extension Ventura County

Wind and rain, the grower's bain

***by* Jim Downer**

All the media are full of stories about the impending El Niño effects and possible flooding rains in California. Although nobody can accurately predict the occurrence of rain, we are certainly due for an increased rain year based on statistical trends and intervals of heavy and light rain incidents. If heavy rains are in the near future, growers will need to take measures to protect their nurseries from the many and disastrous effects of downpours. Physical displacement of soil as erosion and loss of soil are common during heavy rains. While runoff water should not leave agricultural properties it has to move somewhere when rains come, so ditches should be cleared of weeds and other obstructions to permit efficient flow of water. Before rains start, it is a great time to consider some general upgrades and improvement to outdoor growing grounds.

Since many pathogens are splash inoculated from plant to plant or soil to plant, it is imperative to prevent the development of flooded or puddled ground near growing areas. Now would be a great time to lay down additional gravel under container beds or other outside nursery areas. Keeping containers off soil, either with a gravel or fiber mat and gravel system, is imperative when trying to control *Phytophthora* in nurseries. Compacted walkways and beds may become saturated this winter and create ideal sporulation conditions for Oomycetes or water molds which may then move in water flows to new areas of the nursery causing infections where never seen before. Consider boardwalks or additional gravel in known low spots and walkways so that workers don't move infested mud from one part of a nursery to another.

For *Phytophthora* sensitive crops it may be wise to increase the calcium levels in containers by adding additional gypsum now to reduce sporulation and potential spread of disease. It is also wise to use preventative fungicides such as mefenoxam, fluopicolide and phosphorous acid to increase plant readiness for *Phytophthora* increases during wet weather.

This is also a great time for woody plant growers to prune any diseased or dead materials from plants ahead of winter rains because many Ascomycete canker fungi that cause disease in woody plants will have inoculum in dead twigs. When rain comes, spores are splashed to new plants and cause infections. Since this is an El Niño year, it is warm, and warm rains are best for disease promotion. Remove inoculum now: cull and remove weak, diseased or dead plants from the nursery ahead of the rains to cut down on disease spread.

With rains often come winds, sometimes at hurricane force as evidenced in Pasadena, California a few years ago. Greenhouse growers need to consider the effects of wind this winter on their operations and possible crop loss from this damage. Tunnel houses used in producing berries and other crops are most at risk but other greenhouse materials such as polycarbonate sheeting can be detached by wind. Now is a great time to inspect and repair these structures or apply new sheeting as necessary. Wind can also move woody plants so that they rub against each other causing injury to the main stem if tightly spaced. Trees that are blown over due to high winds can be damaged and devalued. Spend time now inspecting trellis systems and staking woody plants to minimize damage that may be coming.

Outdoor nurseries that have planting media storage piles should start now to downsize these piles or provide new tarps in advance of wet weather. Greenhouse operations with media stored outside should ensure that bales are properly covered with

REGIONAL REPORT: Ventura County
continued from page 20

new tarps to prevent saturation of the media. Media bales should be stored off the ground on raised pallets to avoid contamination with soil or mud flows.

The challenge of a wet and potentially stormy winter is to envision what excess water can do in your operation and then try to prepare. Flooding conditions create a time of potential pathogen movement and the best protection for plants is to keep them elevated above the mud and keep workers from spreading it with the movement of machinery or foot traffic. Money spent now on this infrastructure will prevent disease loss later in the spring or summer.

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CAMPUS NEWS

submitted by **Julie Tillman**

Mike Parrella leaving UC Davis


Dr. Mike Parrella

We bid a sad farewell to Michael Parrella, UC Davis entomology professor. Parrella, whose distinguished research career significantly benefited the floriculture and nursery industry in California, has accepted a position as Dean of the College of Agricultural and Life Sciences at the University of Idaho, Moscow, effective February 1, 2016. At UC Davis, Parrella has served as the chair of the Department of Entomology and Nematology and associate dean of Agricultural Sciences. He has also served as the Western Regional Administrator for the IR-4 program; was a board member of the Sacramento/Yolo County Mosquito Abatement District, the California Crop Improvement Association, and the Robert Mondavi Institute for Food and Wine Science; and was a UCNFA administrative committee member.

"I am excited about joining the College of Agricultural and Life Sciences (CALS) at the University of Idaho. The president and provost have a wonderful vision to move the university forward, and CALS has a critical role to play," Parrella said. "As the dean, I look forward to working with faculty, staff, students and stakeholders to make the college all that it can be."

Parrella has a bachelor's degree in animal science from Rutgers University, and a master's and doctorate in entomology from Virginia Tech. His research is focused on developing integrated pest management (IPM) programs for greenhouse and nursery crops with an emphasis on biological control. He has published more than 100 refereed publications and more than 200 trade press/limited distribution articles.

Parrella was also recently elected as the vice president-elect of the Entomological Society of America (ESA), and he will assume the duties as president of the society and preside over the ESA annual meeting in Vancouver, British Columbia, in 2018.

Source: http://www.uidaho.edu/news/news-articles/news-releases/2015-october/100115-calsdean

CDFA NURSERY ADVISORY BOARD REPORT

by **Loren Oki**

What is NAB?

California Department of Food and Agriculture (CDFA) consists of many programs supporting agriculture in the state. If you grow and sell plants, then you probably have a Nursery License to Sell Nursery Stock. The Nursery Licenses are administered by the Nursery Services Program and the fees from the licenses support that program. The Nursery Services Program oversees nursery inspections, quarantines and other activities. The mission is "to prevent the introduction and spread of agricultural pests through nursery stock and protect agriculture and the consumer against economic losses resulting from the sale of inferior, defective, or pest-infested nursery stock" in order to protect agricultural interests and the natural resources of California.

This program also organizes the Nursery Advisory Board (NAB) that "shall advise the Secretary and make recommendations pertaining to his or her responsibilities under those sections of Division 4 of the Food and Agricultural Code and corresponding regulations relating to the sale, production and movement of nursery stock in California." The NAB is relatively new having been formed in 2013.

Who is the NAB?

NAB consists of 12 voting members from the various segments of the nursery industry that are geographically representative.

The industry segments represented may include:

- General Ornamental.
- Annuals/Perennials.
- Foliage Plants.
- Cut Flowers (production & wholesale).
- Retailers (large & small businesses).
- Turf/Sod.
- Sub-Tropical (e.g., citrus, avocado).
- Strawberry.
- IAB assessed nursery stock (grapevines, fruit and nut trees, olives).
- Landscapers (must be licensed to sell nursery stock).

Non-voting members include:

- Chair of California Agricultural Commissioners and Sealers Association (CACASA) Nursery, Seed and Apiary committee.
- Chair of the CACASA Pest Prevention Committee.
- One additional county agricultural commissioner.
- One representative from each of the following organizations: University of California Cooperative Extension, University of California, California Cut Flower Commission, California Association of Nurseries and Garden Centers, California Farm Bureau Federation, National Ornamentals Research Site at Dominican University of California.

Highlights of Most Recent NAB Meeting

The most recent in-person meeting took place in Sacramento at the CDFA Plant Diagnostics Center. The predominant agenda item was on cannabis production and potential regulatory impacts. There were presentations describing the production processes. Research on the crop cannot involve UC or CSU academics since that would compromise the ability of these institutions to receive federal funding. So, new information on cannabis production will have to come from private groups or other institutions that do not receive federal funds. The cannabis nurseries are expected to obtain nursery licenses, so there will be a large influx of fees as a result. There will also be an expectation that the agricultural commissioners will be conducting inspections of growing facilities.

Other items covered were the expansion of Asian citrus psyllid (ACP) quarantine areas resulting from detections outside of the previously quarantined areas, light brown apple moth (LBAM) quarantines in Southern California (these have existed in Northern California for awhile), and Pierce's disease (PD) and glassy-winged sharpshooter (GWSS) updates.

The next meeting hasn't been set, but will be in late February.

Coverage of the CDFA NAB will be a regular feature of the UCNFA Newsletter.

CDFA NURSERY ADVISORY BOARD REPORT

continued from page 22

John Kabashima, Orange County Cooperative Extension Environmental Horticulture Advisor, was a member of the NAB, but on his retirement last July, his vacancy has been filled by Jim Bethke, San Diego County Cooperative Extension Director and Nursery and Floriculture Advisor. I serve as the other UC representative.

The NAB meets in person two times each year in about late February and late August with additional conference calls as needed. Meetings regularly cover the topics of invasive diseases and pests with information presented by CDFA staff on new discoveries and quarantines.

Loren Oki is UC Cooperative Extension Landscape Horticulture Specialist, Department of Plant Sciences, UC Davis.

New Publications from Agriculture and Natural Resources

compiled by **Steve Tjosvold**

We are Going Mobile

UCANR Publications is converting many of our most popular publications to EPUB format (for iOS and other devices that use .EPUB files) and MOBI (for Kindle and other devices that use .MOBI files).

Whiteflies: Pest Notes for Home and Landscape

This recently updated Pest Note describes the identification, damage symptoms, biology and management of whiteflies. Ten common whitefly species and economic hosts — many of which are produced in California nurseries — are described.

Author: M. L. Flint
Publication Number: 7401
http://anrcatalog.ucanr.edu/Details.aspx?itemNo=7401

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