2014 CPS Symposium: 10 Lessons Learned

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The Center for Produce Safety (CPS) held its fifth annual research symposium in Newport Beach, CA at the Island Hotel on June 24-25, 2014. The symposium featured twenty-two CPS-funded research programs and discussions on what the research means to the produce industry. The full technical reports for completed CPS research programs can be found on the CPS website at https://cps.ucdavis.edu/. In this document we have endeavored to identify ten key lessons learned from the 2014 CPS Symposium:

Agricultural Water: An Overview

1. **Sustainable Agricultural Water – Taking Care of a Vital Resource:** Much of the 2014 CPS Symposium focused on the issue of Agricultural Water. The Western United States, where a large portion of fresh produce is grown, are in the grips of an extended multi-year drought and this means there is an ever diminishing supply of water that is of acceptable quality and quantity to meet grower needs. In fact, in recent years nearly 4 million acre-feet of water have been lost by California agriculture because of environmental concerns. Short supplies, no interconnectivity of irrigation water systems and an overdraft of ground water are now forcing growers to look to alternative sources of agricultural water. The alternative of using desalinated ocean water is currently a very expensive proposition at a cost of approximately $5,000-$6,000 per acre-foot of water. Hence, only if new, revolutionary and economically viable technologies become available, is there any hope that de-salinization could be used on the scale needed in commercial agriculture as practiced in the Western United States. This means that the focus for growers right now is how to use less and re-use agricultural water safely and effectively. In the U.S., the use of treated municipal wastewater as a source of agricultural water for produce crop irrigation occurs on only a limited scale but it is anticipated that the use of this type of recycled agricultural water will continue to grow. However, unfounded emotional misconceptions about the use of treated municipal wastewater as a source of agricultural water for produce crop production must be overcome. An extensive review of California's water recycling criteria for irrigation water use and recommendations from a panel of independent advisors was drafted in 2012 and is available from the National Water Research Institute. Another significant opportunity regarding alternative agricultural water sources is the use of "reclaimed tail water", which is water running off the lower end of a field as part of normal irrigation practices that is collected, treated, and reused. However, there is a lack of research that addresses the risk or mitigation strategies for using "reclaimed tail water" for fresh produce irrigation. Hence this will likely become a high priority issue for future CPS research.

Agricultural Water: Preventive Controls

There are only a limited number of agricultural water preventive controls available for growers, with those being: agricultural water monitoring, treatment, use of an application to harvest interval or use of models to understand, predict and manage the microbial quality of agricultural water used on produce farms. The 2014 CPS Symposium provided valuable information about the safe and effective use of each of these preventive controls for agricultural water.

2. **Agricultural Water: Monitoring, What Does It Tell You?:** Monitoring is by far the most commonly used preventive control to assure that agricultural water is of the appropriate microbial quality for its use during produce production. Monitoring can entail sampling for and quantifying either indicator microorganisms (e.g. generic *E. coli*) or actual human pathogens in the water supply (e.g. *Salmonella* or *E. coli* O157:H7). Research discussed at the 2014 CPS Symposium focused on giving context and meaning to agricultural water monitoring results. Research by Dr. George Vellidis of the University of Georgia and Dr. Anita Wright of the University of Florida, both found that *Salmonella* can be regularly found in surface water samples collected from irrigation ponds in the Southeastern United States, but in very low numbers (<1 bacterium/10 Liters). They also found that generic *E. coli* and fecal indicator bacteria generally showed a low correlation with the presence of *Salmonella.* Additionally, Dr. Faith Critzer from the University of Tennessee, also found that generic *E. coli* generally showed a low correlation with the presence of pathogenic *E. coli.* However, when surface runoff occurred, like during rain events, irrigation ponds did more frequently test positive for *Salmonella*. So where is this *Salmonella* coming from? Further research showed that <50% of the *Salmonella* isolates could be attributed to wildlife in the direct vicinity of the irrigation ponds. Where the other 50% of the *Salmonella* is coming from remains unknown. Dr. Vellidis also showed that sampling from the bank of irrigation ponds does a good job of characterizing the overall quality of irrigation pond water microbial quality. So what you sample, where you sample and what results you get all matter!

3. **Agricultural Water: Treatment is an Option!** When agricultural water does not meet microbial water quality standards one option is treatment. However, treatment can be expensive and may have adverse environmental consequences. Dr. Kalmia Kniel at the University of Delaware has been working on a low cost environmentally friendly passive agricultural water treatment system that uses zero valent iron to remove human pathogens from agricultural water. At this year's CPS Symposium Dr. Kniel provided detailed information about how zero valent iron can be used and although it is not right for every situation it certainly is a useful tool to reduce human pathogens in contaminated irrigation water. Additionally, Dr. John Buchanan from the University of Tennessee reported on his on-going research to optimize the use of chlorine and peroxyacetic acid to disinfect contaminated irrigation water quickly and cost effectively. More details will be reported out next year on this important research.

4. **Agricultural Water: Application-to-Harvest Intervals, Is It Possible to Define?** It has been well demonstrated that human pathogens don't last forever in agricultural production environments but exactly how long they do last under specific growing conditions and climates remains unknown. This approach to managing agricultural microbial quality is an attractive alternative to currently proposed FSMA agricultural water monitoring provisions and is simply intuitive for crops such as bulb onions which are field cured under high temperature, low humidity and high UV sunlight conditions which promote human pathogen die-off. As such, Dr. Joy Waite-Cusic has embarked upon looking at application to harvest intervals as an alternative means to manage agricultural water microbial risk. Her preliminary data presented at the recent CPS Symposium were very encouraging in that she saw a 100,000 fold reduction of *Salmonella* and generic *E. coli* in silt loam soils irrigated with contaminated agricultural water. Dr. Waite-Cusic is continuing in this line of research and we await her final report details at the 2015 CPS Symposium.

5. **Agricultural Water: Understanding & Managing Risk is Possible!** While research sponsored by CPS helps us understand the risk associated with various procedures, practices and processes, how does one put it all into context? For example, if low numbers of a human pathogen may be found in agricultural water, what risk does it pose, if any, to consumers whom may eat produce irrigated with that water. Being able to understand and predict how the microbial quality of agricultural water affects the safety of crop is of paramount importance. Dr. Channah Rock from the University of AZ is doing just that, by incorporating agricultural water data she and others have generated into a Quantitative Microbial Risk Assessment

(QMRA) that takes into account how many pathogens are likely to be present, how often they are present, accounts for pathogens growth, die-off or persistence, estimates how many pathogens a consumer may be exposed to, and then estimates the likelihood of a consumer becoming ill. To be able to develop and validate such a complex risk assessment model, lots of data is needed and a lot of that data is being generated by CPS sponsored research. Gathering such data and putting it into a QMRA will potentially permit growers to understand, predict and manage their agricultural water sources better and more reliably. So for example, if it looks like an agricultural water source will be of poor microbial quality when it is needed for irrigation, growers could potentially treat the water but only treat when necessary because they can predict when poor microbial quality agricultural water is present. Dr. Rock is also working on an App to inform agricultural water users about agricultural water conditions in their area. The concept of using an App is simply ingenious, as it makes getting pooled information about agricultural water quality easy, portable and convenient for users such as growers. Look for more information about this App at a future CPS Symposium.

CPS Agricultural Water Whitepaper

In addition to the above highlighted research that was presented at the 2014 CPS Symposium, CPS has recently published a short comprehensive review on the subject of safe and effective use of agricultural water for produce production. This CPS review covers: What do we know about agricultural water?, What have we learned from CPS sponsored research?, and What new research is being funded by CPS? This review is timely as it provides excellent background, along with new and developing information regarding the issue of agricultural water. This comprehensive review also serves as an excellent resource for anyone who has or will be implementing science and risk based on-farm preventive controls or for anyone who will be participating in the ongoing FSMA policy debate regarding development of appropriate and effective agricultural water preventive control standards.

Managing Routes of Produce Contamination

We know from experience that just because a hazard (e.g. lightening) is present, it doesn't mean that any harm will come to you. It's the same for human pathogens in the agricultural environment, just because they are present doesn't tell you how risky they may be, as they first have to find their way onto produce to create a risk. The 2014 CPS Symposium provided a number of insights regarding risks, as well as, how well human pathogens can transfer to produce from agricultural water, animals, soil amendments and in the postharvest produce handling environment.

6. **Agricultural Water: Splish / Splash:** Can splash from agricultural water overhead sprinkler irrigation systems contaminate produce? That's exactly the question that Dr. George Vellidis is looking into at the University of Georgia and his preliminary results indicate that indeed that contamination seems to be directly proportional to the distance produce is from the ground. Dr. Faith Critzer at the University of Tennessee is also looking into how effective plasticulture production is at preventing contaminated agricultural water from contaminating produce. Her preliminary results indicate that drip irrigation under plasticulture reduces the likelihood of produce contamination when compared to drip irrigation on bare ground, but it does not eliminate the risk.

7. **Are Animals a Big Contributor to Produce Contamination?** Produce is most often grown outdoors where wild animals have access to fields. Dr. Vivian Wu's team at the University of Maine reported that white tail deer in Maine had a 2% prevalence rate for the presence of *E. coli* O157:H7 in their feces and that direct contact between produce and animal feces will likely cause produce contamination. Dr. Martin Weidmann from Cornell University reported that deer are much more important than birds with regard to their ability to contaminate produce fields and that pathogen dispersal occurred when riparian corridors were present to allow terrestrial animals to move freely between wild lands and produce fields. Additionally, in the desert Southwest, Dr. Michele Jay-Russell reported that rodents were found

to be carriers of *Salmonella* about 4% of the time but they did not serve as a carrier for pathogenic *E. coli*. However, feedlot cattle and feral pigs were significant carriers of both pathogenic *E. coli* and *Salmonella*. This research again points out that risks posed by the presence of various animals is not equal and that terrestrial animals, especially those which are commensal with human activities may pose the greatest risk by being common carriers of human pathogens.

8. **All Soil Amendments are Not Created Equal:** Many materials are used as soil amendment to increase soil tilth in produce fields. One commonly used soil amendment is extruded and thermally treated chicken pellets. Research from Dr. Juping Xiang at Clemson University revealed that *Salmonella* can become resistant to such heat treatments when chicken litter or manure is aged because the *Salmonella* adapt to these drying conditions. This means that one must be aware of the condition and history of raw materials one is processing into thermally treated chicken pellets. It is critical to know the composition, moisture content and age of the raw materials used to produce thermally processed chicken pellets as the times and temperatures needed to inactivate human pathogens are greater for aged and low moisture content raw materials. The information derived from Dr. Jiang's work demonstrates that it is unwise to take a one size fits all approach to preventive controls, and careful validation and verification of preventive controls such as thermal treatments of soil amendments is required.

9. **Postharvest Interventions are Possible:** Currently, the most effective means of preventing foodborne illnesses associated with produce consumption is a pro-active approach which prevents produce from being contaminated in the first place. However, Dr. Trevor Suslow of the University of California Davis has explored a number of postharvest interventions to reduce produce safety risk; such as the use of hot water with peroxyacetic acid to wash cantaloupes and reduce microbial contamination. Dr. Suslow found that hot water washes with peroxyacetic acid can indeed be an effective means to reduce the number of pathogens present on the surface of whole cantaloupes by about 100 fold, but the treatment must be carefully controlled to reduce the potential for heat injury to the edible flesh of the cantaloupe. Dr. Suslow found that cantaloupe heat damage susceptibility varies significantly by cantaloupe maturity and cultivar. Dr. Suslow also reported on results regarding the use of ozone in wash water in the food preparation areas and sinks of restaurants to prevent produce cross contamination. He found that chilling the wash water, lowering the water pH, draining entrapped water external to the wash basin and keeping the water free from as much organic matter as possible, greatly aided in the efficacy of ozone to prevent produce-to-wash water-to-produce cross contamination. Dr. Nitin Nitin of the University of California Davis is also working on developing a method to directly measure the oxidative stress response of *E. coli* and *Listeria monocytogenes* when exposed to wash water disinfectants using Nuclear Magnetic Resonance (NMR) technology. Dr. Nitin's research may provide a means to study the efficacy of new novel wash water antimicrobial compounds directly and lead to quicker development of such compounds.

10. **Turning Research into Food Safety Practices:** The information derived from research sponsored by CPS is all well and good but taking action on the knowledge you have gained where you work is where the real value of CPS sponsored research is derived. Understanding and communicating the results of CPS sponsored research with your co-workers and management team is critical in helping everyone in your organization to understand produce risks and it enables everyone to make better informed decisions on how to best allocate limited food safety resources in your operations. Planning, validating, implementing and verifying preventive controls in your produce operation that are science-based and risk-based is hard work but with the information provided by CPS sponsored research, the task can be made a little easier. Please use this information and take the opportunity to operationalize these learnings to enhance the safety of produce for consumers.