Topics in Subtropics Newsletter

University of California Cooperative Extension

Fresno, Kern, Madera, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara,Tulare,&Ventura Counties

News from the Subtropical Tree Crop Farm Advisors in California

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High Density Avocado Planting: A Potential for Profit?

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Avocado acreage in San Diego has been declining because of high cost of production caused by urban development and especially the cost of water reaching to up to $2,000 per acre-foot in 2000. In addition, global production increase and the growth in the supply of avocados more than its demand caused price and grower returns declines in the US and in California. The University of California Cooperative Extension (UCCE) specialists and advisors for years have conducted experiments and field trials to develop management strategies including irrigation, nutrition, and pruning for improving productivity and seeking cost effective practices to increase sustainability of producing avocados in the region.

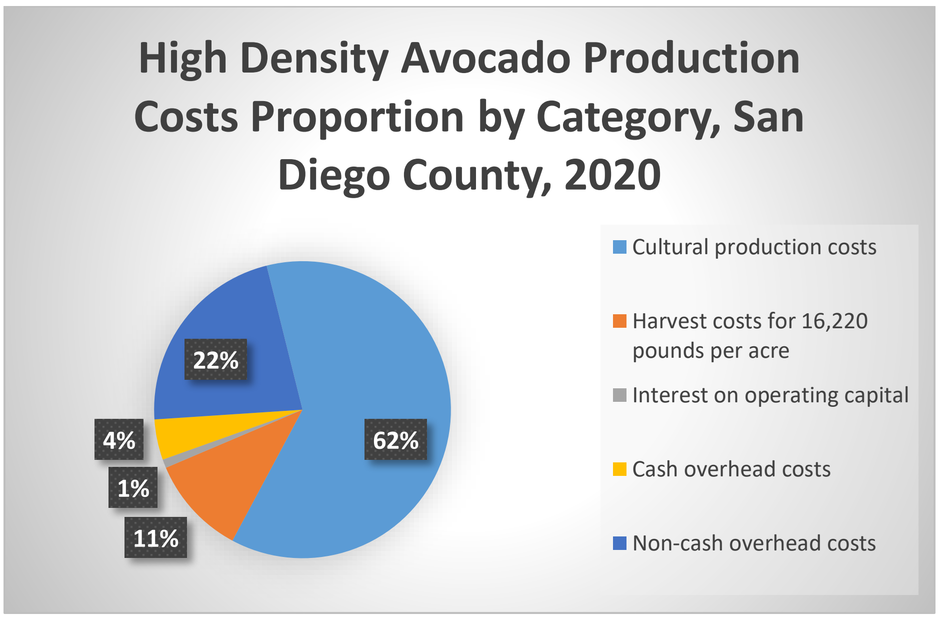
In 2011, Dr. Gary Bender, Farm Advisor, now emeritus in San Diego County initiated a field trial/experiment in Valley Center, California to study the productivity, water consumption and punning strategies of high density planting in Hass and lamb Hass varieties. The experiment was conducted at a cooperating grower's field from 2012-2017 with planting space of 10'x10'; 430 trees per acre.

High Density Planting in Valley Center, CA
Picture by Gary Bender, Farm Advisor Emeritus, San Diego County

Details about the experiment and results were published by Dr. Gary Bender (High Density Avocado Production A Method to Improve Yield per Acre, Winter 2018 / From the Grove / 35), https://www.californiaavocadogrowers.com/sites/default/files/documents/11-High-Density-Avocado-Production-Winter-18.pdf

In order to estimate the profitability of these practices, we conducted a full enterprise budget analysis of a high density planting of the Hass variety to estimate establishment costs (investment requirement) and production costs and returns. In addition to the experiment data, we collected other production practices from the grower cooperator of the experiment such as fertilization, pest and disease management and harvesting as well as made references to our sample cost study of 2011 (Takele, et. al.). The full study is published in the Department of Agricultural and Resource Economics website; https://coststudyfiles.ucdavis.edu/uploads/cs_public/b4/3d/b43d58d9-1e91-4a3e-80f9-a2edb14958b0/2020avocadohighdensitysandiegocounty.pdf

Costs and Returns: The total establishment cost estimate (cumulative of the first 6 years costs and returns) for high-density avocado planting of 10' x 10" (430 trees per acre) is $17,597 per acre. The annual production cost estimate is $16,233 per acre. The pie graph below shows the proportion of costs by category.



Returns include a gross return of $22,494 per acre given the average experiment yield of 16,220 lb. /acre. Our estimate also shows gross margin (or returns above cash operating costs) at $9,857 per acre. Growers often consider gross margin as profit if there is no debt on the farming operation. Deducting depreciation, gross margin also approximates taxable income. In addition, the study shows a $6,260 per acre net return or return to management (because management charges are not included in the study.

Using break-even analyses to show the price effect of profitability, it would require $0.78 per lb. to cover all cash operating costs and $ 1.00 per lb. for covering the total production costs. Given the average price of $1.39 per pound (the average for San Diego County Hass prices; Agricultural Commissioner report for 2014-17), the enterprise shows a gross margin of $0.61 per pound and net returns (returns to management) of $0.39 per pound. In order to accommodate yield and price variations that may exist in the County, the study has included a range analyses of gross margin and returns to management at various yield and price combinations. Growers can identify their gross margin and returns to management based on their yield and prices received.

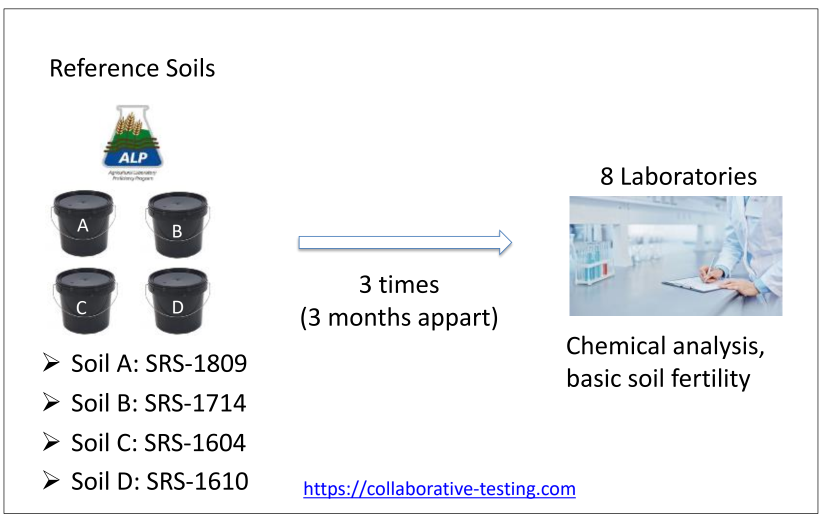
Your Soil Chemical Analyses May Not Be as Accurate as You Think

Andre Biscaro, UCCE Irrigation and Water Resources Advisor, Ventura County,

Deciding which laboratory to send a sample to can be a daunting task as there are no public data reporting the accuracy of the analyses performed by agricultural laboratories, and there isn't a "true" certification program in the U.S. Although a lab may participate in a proficiency program such as the Agricultural Laboratory Proficiency (ALP) program or the North American Proficiency Testing (NAPT), these programs are not mandatory, nor do they certify lab quality. A laboratory can choose to participate in these programs whenever they decide, and you will never know if/when they fail it. Therefore, laboratories are chosen based on "word of mouth" and prices, which can vary significantly. Because of the absence of data, growers, farm managers, consultants, environmentalists and even researchers are left without a reliable means by which to select a testing laboratory. Without a reliable soil test, significant miscalculations in fertilizer recommendations can occur, leading to drastic effects on profitability and the environment. A study was conducted in 2019 to assess the performance of soil testing laboratories.

Accuracy and Precision Assessment

Four reference soil samples from the ALP program were submitted to eight commercial Ag laboratories in the Western U.S. (seven in California and one in Idaho) for typical fertility analyses. The same four reference soil samples were resubmitted two more times totaling three rounds, sent approximately three months apart each round, in order to assess the precision of each laboratory (or their capability to reproduce the same results over time).



Standard reference soil samples were selected from the ALP program archives, each previously analyzed by a minimum of 30 credible laboratories, in triplicate for each soil sample (totaling 90+ analyses per reference soil.) The median and median absolute deviation (MAD) of these 90+ analyses per reference soil were used to assess the accuracy and precision of the eight laboratories assessed in this study. While the accuracy assessment is focused on contrasting each analysis with the ALP medians, the precision assessment is focused on the variability of the analyses across the three rounds (same reference soils analyzed at different times.) Sample IDs were modified and submitted to each laboratory so they wouldn't be aware of the objectives of the study. Names of laboratories are not disclosed to follow university policy; laboratories are referred as #1 to #8 for discussion purposes.

Each reference soil was analyzed for nitrate, phosphorus, extractable K, Na, Ca and Mg, SO_4-S, electrical conductivity (ECe), Cl, Ca, Mg, Na, B, pH and five micronutrients. Some labs provided additional analyses in their fertility package, such as soil organic matter, estimated and measured CEC and others, however, these were not used in this study since they were not performed by all laboratories. Nineteen analyses performed on four reference soils by eight laboratories three times equals a total of 1,824 analyses, or

228 per laboratory. While that is a rich dataset, trying to create a performance rank for the laboratories across all analysis types is quite challenging since there are multiple types of soil analyses, extraction methods and units. For that reason, performance standards used by the ALP program were applied to this project in order to assess the accuracy and precision of the analysis performed by the laboratories. Eight analyses were chosen for this assessment: Olsen P, extractable K, Ca and Mg, ECe, pH, sodium adsorption ratio (SAR) and DTPA Zn. For the purpose of accuracy assessment, each of these analyses were attributed a pass or failure score (fail if lower than *median–2.9*MAD* and if higher than *median+2.9*MAD*), totaling 96 scores per laboratory (8 analysis types, 4 reference soils and 3 rounds). The precision assessment was based on the relative standard deviation of each analysis across the 3 rounds.

Results and Discussion

The table below summarizes the overall accuracy and precision scores for each laboratory based on the method described above.

	Laboratory #							
	1	2	3	4	5	6	7*	8
Accuracy (%)	77	52	62	68	71	77	88	21
Precision (%)	72	54	63	58	56	69	84	17

*Only participated in rounds 1 and 2

Although all labs presented certain inaccuracy and imprecision, some stood out. Laboratories #2 and #8 were consistently inaccurate and imprecise, while laboratories #1 and #7 were the most accurate and precise. Laboratory #8 in particular presented the poorest performance for both accuracy and precision. Laboratories #3, #4, #5 and #6 presented varying accuracy and precision. These patterns of accuracy and precision are illustrated in the three graphs below.

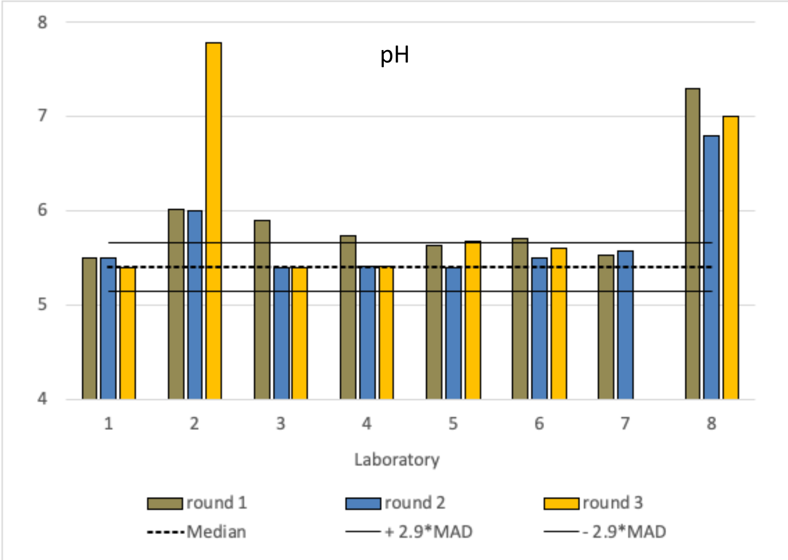
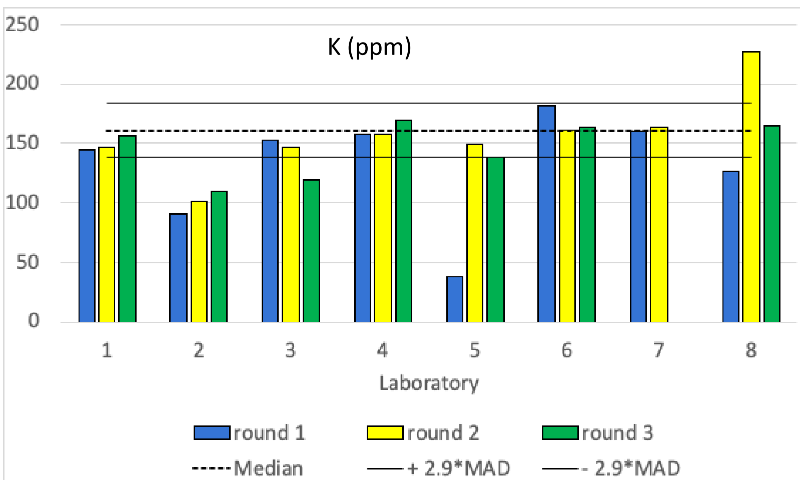


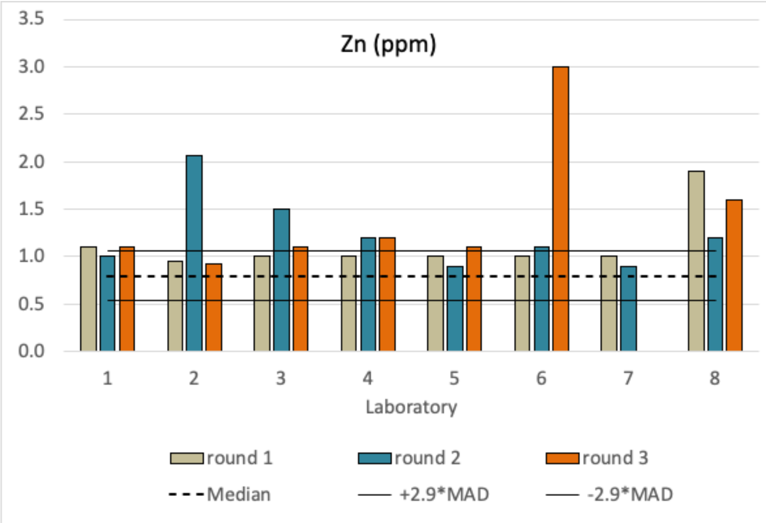
Figure 1 illustrates the results for saturated paste pH for soil C. Listed is the pH median and +/- 2.9*MAD (Median Absolute Deviation), with results for each lab and each round. Labs #1 and #7 were the most accurate over all rounds. Labs #2 and #8 had high bias, and lab #2 was imprecise (inconsistent). Due to funding limitations, only two rounds of samples were submitted to lab #7.

Figure 1. Soil pH analysis by the saturated paste method performed by eight commercial laboratories for soil C.



Results for exchangeable potassium analysis by ammonium acetate for soil C (**Figure 2**) illustrates a common occurrence of accuracy levels observed across most reference soils used in this study. Generally, labs #1 and #7 consistently reported results near the median.

Figure 2. Exchangeable potassium analysis by ammonium acetate extract performed by eight commercial laboratories for soil C (SRS-1604).



Results for Zn extractable by DTPA for soil A (**Figure 3**) show a general trend of all eight labs reporting higher Zn values relative to the median for this standard reference soil of 0.9 ppm. Labs #1, #4, #5 and #7 generally reported equivalent Zn concentrations for each round. Labs #2, #3, #6 and #8 were inconsistent across the three rounds. Lab #6 in particular reported values that varied by 300% across the three rounds.

Figure 3. Zinc analysis by the DTPA method performed by eight commercial laboratories for soil A (SRS-1809).

I encourage the readers of this article to go back to the table shown above and reflect if it is fair that you and/or your clientele may be getting results with acceptable accuracy only 2 to 5 times out of 10 (20-50% accuracy). It seems like there is a case for lab users in California to advocate for a proficiency program where labs have to meet a minimum accuracy and precision standard to serve their clientele.

Need for Consistency

Besides the accuracy and precision parameters assessed in this study, it seems like consistency is an overall challenge for the lab industry. Consistency of methods used for certain analyses, reporting of the methods and units, and of the interpretation of the results (e.g. graphs illustrating sufficiency and deficiency ranges) varied. Although it is the responsibility of the client to verify the methods used and request the most pertinent information for their application, many growers and farm managers are not familiar with the intricacies of soil analyses and nutrient management. Hence, providing an electrical conductivity analysis in 1:1 or 1:2 extraction instead of the standard saturated paste extract (ECe) can lead to misleading conclusions and inappropriate management decisions since the literature for most salinity thresholds for crop yields were defined with the saturated paste extract method. Another observation in regard to the analysis type is about the phosphorus extraction method used for soils with different pH, where some labs used the Olsen extraction method for soils with pH below 6.0, and others utilized the Bray P1 method.

The author wishes to acknowledge the following contributors to this article: Robert Miller, ALP Program Director, former Extension Soil Specialist UC Davis; Dirk Holstege, former Director of the UC Davis Analytical Laboratory; Steve Orloff (in memoriam), UCCE Advisor, Siskiyou County; Tim Hartz, CE Vegetable Crops Specialist (retired), UC Davis; Ben Faber, UCCE Advisor, Ventura County; Anthony Luna, SRA, UCCE Ventura County; and Eryn Wingate, Agronomist, Tri-Tech Ag Products.

The rhizosphere, defined as the soil environment that surrounds the plant roots, is a rich and diverse habitat for microbes. Some members of the rhizosphere microbiome (or collection of microbes), are good, others bad while many are just there and don't provide any benefits or harm to the host. One function of the good microbes in the rhizosphere is to help facilitate the availability and assimilation of nutrients and water from the rhizosphere. Just like the human gut, the plant rhizosphere conveys key nutritional functions and the analogy was made that "plants wear their gut on the outside". One example is the symbiotic relationship between legumes (peas, beans) and rhizobia. Those bacteria help the plant fix atmospheric nitrogen in exchange for carbon supply. Another example is the symbiotic relationship between the plant and mycorrhizal fungi, whereby the mycorrhizae receive carbon from the plant in exchange for increased nutrient uptake (principally phosphorus and nitrogen). There is undeniable evidence that plants have developed a mechanism for recruiting good microbes to cope with environmental stress such as protection against opportunistic pathogens or drought. The rise of 'omics' technologies have helped profile entire microbial communities associated with plants and shed light in their biological functions. This research has fueled the development of novel commercial bioproducts to address the increasing consumer's demand of environmentally-friendly products. As a result, there has been several commercial 'probiotics' and 'prebiotics' that have been marketed for agricultural use including many biocontrol agents such as fungal- (e.g., *Trichoderma*) and bacterial- based (e.g., *Bacillus, Streptomyces*, or *Pseudomonas*) bioproducts.

One goal of my research program is to identify beneficial microbes for tree and vines crops, promote practices that support the presence and abundance of beneficial microbes and figure out how good microbes help combat pathogens and support plant health. As part of a collaborative project (UC Riverside, University of Florida, USDA-ARS) funded by the California Citrus Research Board and the USDA-NIFA, we profiled the microbiome of citrus trees in the context of Huanglongbing disease (or HLB). HLB is a highly destructive and lethal disease to all commercial citrus cultivars making it a threat to citrus production globally. Finding strategies that do not only rely exclusively on management of the insect vector of the bacterium (the Asian Citrus Psyllid), is a priority to the citrus industry. In our research, we found that there were significant tissue-specific microbial shifts occurring within the citrus microbiome as trees get sicker, especially in the root compartment. As HLB progressed, there were depletions of beneficial species in roots, such as mycorrhizal fungi, and enrichments of parasitic microorganisms, such as *Fusarium* and *Phytophthora* (see Figure). HLB-affected trees decline because of the clogging the phloem sieve tubes, which limit movement of sap and translocation of sugar to the roots, hence leading to feeder root collapse. Once tree is weakened, it becomes more susceptible to pathogens such as *Phytophthora* which further weakens the trees and exacerbate above ground HLB symptoms. In addition, several studies from Florida suggested that cultural practices that supported root health and rhizosphere microbiome richness and diversity limited root collapse.

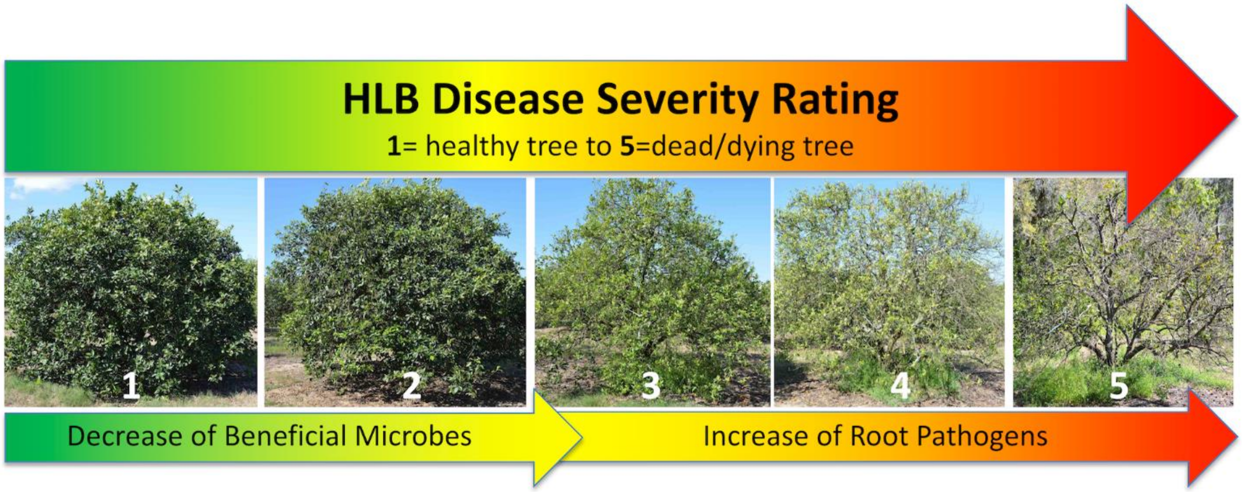


Figure: Citrus decline caused by HLB (https://apsjournals.apsnet.org/doi/10.1094/PBIOMES-04-20-0027-R - Ginnan et al. 2020. *Phytobiomes*); canopy thinning, wood dieback, feeder roots decline, collapse of beneficial microbes and enrichment of pathogens in roots.

Our group was recently awarded another research funding by the USDA-NIFA Emergency Citrus Disease Research and Extension program (project director, M.C. Roper, Microbiology and Plant Pathology, UC Riverside). This research effort in collaboration with UC Agricultural and Natural Resources, UC Davis, University of Florida, and the USDA-ARS aims at investigating the root collapse associated with HLB-impacted trees and finding ways to mitigate it by promoting root health. In the proposed work, we will test how different sectors of the root microbiome contribute to or lessen fibrous root loss and if soil amendments (e.g., humic acid treatment, mulching) and planting of HLB tolerant rootstocks (*Poncirus trifoliata* and *P. trifoliata* hybrids) can be used to mitigate root loss associated with HLB in Florida, and how tree respond to those practices under a HLB free environment in California. While these approaches will not cure trees from HLB, it will provide a science-based information for strategies that support root and tree health and sustain orchard longevity until remedies are discovered.

Current Challenges for California Avocado Weed Management: Herbicide Resistance, Lack of New Chemistries, and Climate Change

Sonia Rios, UCCE Subtropical Farm Advisor Riverside/San Diego County

Photo 1: Weeds in conventional avocado grow during early summer. (Photo Credit: Sonia Rios)

Current status in California

Today, California is the leading producer of domestic avocados and home to about 90 percent of the nation's crop. Most California Avocados are harvested on approximately 50,000 acres from Monterey through San Diego by nearly 3,000 growers. Ventura and San Diego top the list of avocados producing counties in California (CAC 2021). Pests in avocados relative to those in other tree fruits have been historically light, until the last decade. In southern California the climate supports a biologically-based system of integrated pest management (IPM) and had served the growers well until the recent introduction of new pests, such as avocado thrips, persea mite, polyphagous shot hole borer, and the most recent threat, the avocado lacebug. Due to the increase of invasive insect pests, the weed management portion of avocado IPM has become a lower priority. However, with the increase of herbicide resistance biotypes, due to the lack of chemistries available, a decrease in preemergent practice, and the overuse of the popular, yet controversial, postemergent, glyphosate. Integrated Weed Management (IWM) needs to return as a priority as we run the risk of losing an important broad spectrum postemergent forever.

The word “weed” has been defined as a plant out of place, an unwanted plant, or a plant that is a pest in that it interferes with crop or livestock production (Merriam-Webster, 2021). The term is typically applied to any plant species that often becomes a pest. Weeds are the costliest category of agricultural pests (Oerke 2006). Worldwide, weeds cause more yield loss and add more to farmers’ production costs than insect pests, crop pathogens, root-feeding nematodes, or warm-blooded pests (rodents, birds, deer, and other large grazers). Weeds are the most acute pest in agriculture with an estimated annual global damage of around 40 billion dollars per year. In Australia and the USA, the cost of managing agricultural weeds exceeds 30 billion dollars per year (Lawes & Wallace, 2008). Young, newly planted avocado trees critical weed-free period for new orchards is the first three months after planting. Serious weed competition can cause young trees to have stunted growth, reduced fruit size and yield. This can result in significant economic losses.

Weeds compete directly with avocado trees for needed water and nutrients during the growing season (Photo 1.). Keeping the weed-strip mostly clear of weeds can save the grower on average between 50,000 and 100,000 gallons of water per acre per year (Washington State Univ. 2021) and for a county like San Diego, which some areas cost close to $2,000 an acre foot (Takele et. al. 2020), not controlling weed populations will cost more money down the road. Weeds can also interfere with irrigation of the trees by blocking the sprinkler pattern, causing uneven or inefficient irrigation, or by plugging sprinklers. Micro-sprinklers are even more susceptible than other styles of sprinklers because they are often low to the ground.

Weeds can greatly out-compete the trees for nutrients, especially nitrogen. This complicates the growers attempts to create an efficient nutrient balance in the trees, as it is never certain from one application to the next what percentage of the applied nutrient will enter the trees, or when it will get there. Trying to compensate for weed growth by applying higher rates of nitrogen fertilizer may increase the nutrient in the tree, but more often leads to greatly increased weed growth.

Certain insect pests, such as mites of tree can live in host-plant weeds can multiply there and migrate up into the trees causing direct damage to the fruit resulting in significant economic losses. Tree-damaging from rodents such as gophers, ground squirrels, and voles will increase because these pests like to hide and overwinter in the habitat created by weed cover and while there, they feed on tree bark and roots and cause damage. There have been a handful of smaller size groves that I have seen lost to phytophthora because gophers will start to chew on the trees root systems leaving them vulnerable for the pathogen to enter the tree. These rodent pests will be deprived of habitat next to trees if weeds are controlled, especially in the fall season. Significant weed cover under trees also makes worker and machine access difficult (e.g., dangerous for ladder work) and can also be hazardous as coyotes and rattlesnakes can make themselves comfortable in the vegetation. The weed habitat also encourages litters of coyote pups being born in the orchard which can eventually ruin one's irrigation system when the pups start to teeth (Photo 2.).

Photo 2. Drip irrigation pipe and other such materials, when chewed by coyotes, have the appearance of having been compressed and shredded as if chewed by dogs. (Photo Credit: Sonia Rios)

Maintaining a bare soil surface under trees can minimize damage from early spring frosts. Bare soil surfaces, free of weeds or plant residue, absorb more heat during the day. The release of the absorbed heat at night can increase orchard temperatures by a few degrees (3°- 5°), which can be enough temperature to save an orchard from permanent damage. This is commonly referred to as the radiant heat benefit. Although temperature changes are modest, they can be enough to prevent fruit loss during winter freeze snaps and early spring freeze events.

Weed biology

Understanding a weeds biology is an important component in developing a preventive approach. Weed species have strengths and weaknesses that make them vulnerable or resilient at different stages in their life cycle. Weeds can be labeled by their lifecycles (germinate, grow, reproduce, and die), annual, biennial, or perennial. Annual weeds complete their life cycles during a single year. This category is often sub-divided into two groups: the summer annuals (weeds that germinate and grow in the spring and the summer like palmer amaranth) and the winter annuals

(weeds that germinate and grow in the fall and the winter like hairy fleabane) (Photo 3). However due to climate change rising temperatures, and southern California's mild climate, it seems as though most winter annuals can be found year-a-round now. Biennial weeds have a two-year life cycle. They germinate, emerge and store food in the first year. During the second year, the plant produces a flower stalk, flowers, sets seed, then dies (bull thistle). Perennial weeds have life cycles that last three or more years. Some perennial plants reproduce only by seed or can produce proliferate rhizomes, stolons, and tubers. Weeds move between and become established in different locations by the production and dispersal of seeds. Seeds can be spread within and among sites via gravity, wind, water, forceful expulsion, or through the movement of animals and people. Seeds that are released from the parent plant enter the soil seedbank, where they can remain for varying amounts of time sometimes the seeds may remain dormant for years or possibly even decades. Weeds can also be introduced into fields through manure, compost, hay, straw, animal feed, contaminated crop seed, or other materials. Weed seeds enter livestock systems from forages, grain, and palletized feed products. A portion of weed seed present in feed can remain viable after passing through an animal's digestive tract (Katovich et. al. 2005).

IWM

There are many weed control strategies used by avocado growers, depending on the types of weeds, area to be controlled, availability and feasibility of labor, and whether the site is under conventional or organic production practices. Unfortunately, these is "no one size fits all" approach. There are often a mix of annual and perennial weeds growing in the orchard simultaneously, in different stages of growth, which can make controlling the population more difficult. Soil types, site location, and irrigation, are all variables that contribute to different weed pressures for different orchard locations. Some weeds introduce themselves to certain areas of an orchard, and grow in patches, and others may cover the entire orchard floor. These are some reasons why one method or product used will not control all of the weeds at a site. Successful weed management in orchards requires a year-round system combining different strategies. The first step in an IPM program is to correctly identify the types of weeds that are present, weeds can be identified with the help of UC IPM Avocado Guidelines: https://www2.ipm.ucanr.edu/agriculture/avocado/Common-and-Scientific-Names-of-Weeds/ By knowing the weed and its life cycle a grower of Pest Control Advisor (PCA) can determine the accurate rate and timing of herbicides or other treatments to obtain the most reliable results.

Mulches and Cover Crops- Good? Or Bad?

Photo 4: Cover crops are seeming becoming popular. Ventura Grower, Chris Sayer has been a pioneer in this type of cultivation practice. Cover crops can increase soil microbial activity and improve water infiltration and storage. (Photo Credit: Chris Sayer)

Because soil open to sunlight helps weeds grow and complete, mulches are used to help manage weeds in some organic production systems. The mulch provides a physical barrier on the soil surface and must block nearly all light reaching the surface so that the weeds which emerge beneath the mulch do not have sufficient light to survive. Mulch can also be very beneficial to maintain water and soil moisture in the ground. Cover crops can be planted in the drive row and under trees to improve soil fertility and suppress weeds (Photo 4). When the cover crops are mowed, they increase the organic matter in the soil. Cover crops also increase soil microbial activity and improve water infiltration and storage. The presence of cover crops will require more water and nutrition than a bare weed-strip to ensure that the trees are getting enough nutrition. And they may increase the risk of rodent damage by providing habitat. Cover crops can be mowed and blown or raked into the tree row as mulch. Some cover crops are annuals and will die on their own at the end of the life cycle. Others are perennials and can persist for a number of years.

Mechanical Weed Control

Mechanical weed control is critical for managing weeds, especially in organic systems. Traditionally in row crops, such as corn or soybeans, mechanical cultivation is generally necessary for adequate weed control. Mechanical weed control includes the use of preplant tillage such as plowing, disking, and field cultivating. These types of primary and secondary tillage can help reduce the rate and spread of certain perennial weeds and can also kill emerged weed seedlings and bury weed seeds below the germination zone. However, due to the unique topography of where avocados are planted and shallow root system, growers are limited to which mechanical control methods are used due to the steep slopes where the trees are planted. Mechanical control can also be a nightmare if the weed species you are trying to disk under contain tubers or rhizomes because the root segments can re-sprout, establish new roots and start the life cycle all over again. As mentioned before, please identify your weeds species before your plan of attack! In avocados, the best mechanical method is also the most expensive and laborious, hand weeding. Even with this method, hand weeding has its obstacles. Most species of weeds, when pulled from the ground and left in the field, can actually replant themselves and rejuvenate their root system and go into reproduction mode almost immediately as a defense mechanism and disperse seeds in order to help the biotype survive. Some preventive tactics can be classified as sanitation: removing or destroying weeds in fields or near fields before they flower, and release weed seed. Weed seeds can live for a number of years, depending on the species and whether the seed is exposed or buried beneath the soil surface. Ultimately, in order for any type of mechanical method to be successful, weather it is weeding by hand or machine, the main goal is to remove the weeds BEFORE they go to seed and practice sanitation methods to prevent further spread.

Most Popular Method of Control: Chemical Weed Control

If used correctly, herbicides can be a useful tool in an IWM program (Photo 5). Conventional growers can use both preemergent and postemergent herbicides to eliminate weeds. Organic growers are limited to a handful of pre-emergent, non-selective contact materials. Herbicides modes of action kill vegetation in many different ways. Preemergent products are directed at controlling the germinating weed seed before it emerges from the ground and are best at preventing annual weeds such as horseweed and hairy fleabane. Postemergent products are directed at controlling weeds that are emerged from the ground and are easily visible such as thistles and

Photo 5: Chemical weed killers, when used properly, can be an effective component of an Integrated Pest Management program. UC ANR, Dee Vega using chemical control on an avocado herbicide trial. (Photo Credit: Sonia Rios)

malva. An herbicide may be selective (i.e. a grass only herbicide will only kill grass and not broadleaves) or non-selective (broad spectrum, i.e. grass and broadleaves). Post-emergent products can also be divided into contact or systemic herbicides. Contact herbicides such as glyphosate can kill any plant tissue it comes into direct contact with the above-ground parts of the weed. Systemic herbicides enter the weed via root system or through the cell guards located on the leaves and will circulate through the phloem and kill the weed from the inside out by causing havoc within the plant cells.

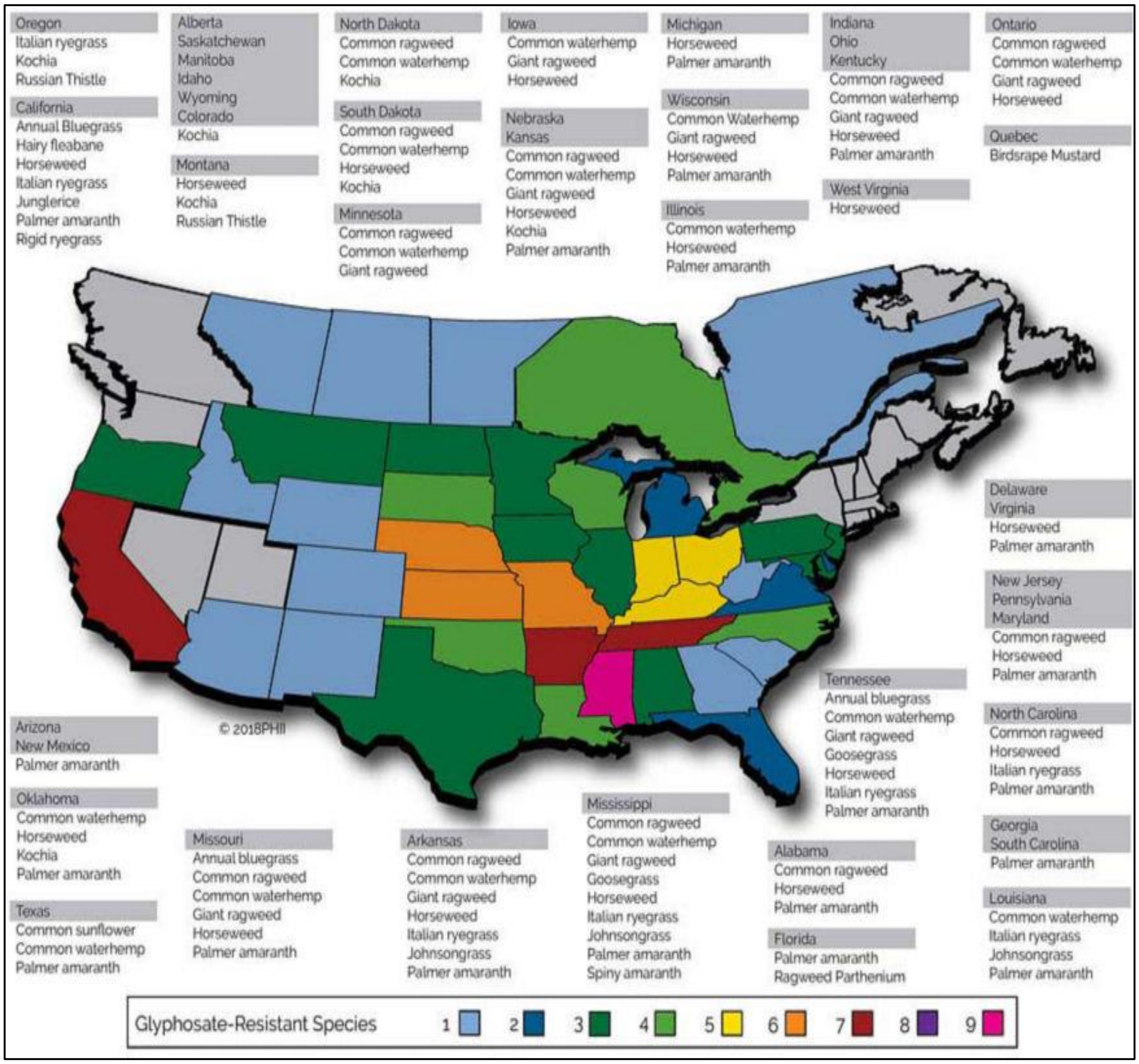
Preemergent, soil-active herbicides may provide long-term or seasonal control of developing weeds. The drawback to preemergents are they need to be incorporated into the soil mechanically or moved in by water or by rainfall. The incorporation time varies from herbicide to herbicide but usually only has about two weeks' time to incorporated before the. herbicide is no longer active. Systemic herbicides can move from the foliage to the roots and eliminate more difficult to control weeds, particularly perennials that have hardy root systems that produce new top growth. Some of these herbicides such as simazine must be used with caution as they may travel or leach in sandy soils and can also travel to the avocado tree's roots, so it is important to use caution and always follow product label guidelines to avoid drift and major tree injury (Photo 6). Newly planted avocado trees with green bark are very sensitive to herbicide damage and require protection from contact with herbicides. The sleeve tubes that come with the trees from the nurseries should stay on after planting and for as long as they can (usually 18-24 month's time is the average) also trunk or painting the bark white can protect may also work, however may not be as effective as a direct barrier protection . Herbicide treatments in the fall often give the best results for perennial weeds, as the herbicide moves to the roots along with the sugars the plant is moving to store for next year. Weeds are tougher in the spring, and harder to eliminate. Orchard site is a factor in determining treatment choices, as certain herbicides may be de-activated in soils with more organic matter or clay and thus not work as well as expected.

Photo 6: Glyphosate drift damage on 4 year-old avocado tree, this tree was positioned towards the border of the orchard (Photo Credit: Sonia Rios)

Most troublesome weeds in avocado orchards today: herbicide tolerant and resistant biotypes

Environmental factors and production practices influence species composition at any location, a phenomenon known as selection pressure. Under constant conditions, the weed community will become dominated by species that thrive under those conditions. If this steady state is upset by a change in management practices, a weed shift may occur, resulting in a community dominated by different species adapted to the new conditions (Hanson et al. 2013). This weed shift can be caused by agronomic and horticultural practices (tillage, fertility, irrigation) or by the use of herbicides. Some species will be less susceptible (more tolerant) than others to any management practice, and repeated use of the same control strategy can shift weed populations to become dominated by naturally tolerant species. Herbicide-resistant biotype, weeds tends to be in modern, high-intensity agricultural cropping systems due to a high reliance on herbicides. According to the International Survey of Herbicide Resistant Weeds (weedscience.org 2021),

Figure 1. Confirmed cases of glyphosate resistance in North America as of spring 2018. California currently has 7 glyphosate-resistant weed species. Heap, I. The International Survey of Herbicide Resistant Weeds. Available www.weedscience.com (Photo Credit: PIONEER).



since the first confirmed report of a resistant biotype in 1957, herbicide-resistant weed biotypes have been reported in at least 60 countries and include more than 400 unique species-herbicide group combinations. The United States has more herbicide-resistant biotypes (162) than any other country and California accounts for 21 of these. In recent years, glyphosate resistance (Figure 1) and multiple resistances (resistance to two or more herbicides with dissimilar modes of action) have also emerged as major problems in permanent cropping systems, such as hairy fleabane, where in California's San Joaquin Valley, most populations are resistant to both glyphosate and paraquat. Interestingly, while herbicide resistance in the United States as a whole is primarily found in broadleaf weeds, California has more herbicide-resistant grasses or sedges (15) than broadleaf species (6) (weedscience.org 2021).

In contrast to the rest of the United States, where herbicide resistance problems are centered on agronomic crops, the greatest problems with herbicide resistant weeds in California are in orchards, vineyards, flooded rice, roadsides and irrigation canal banks. Herbicide resistant weeds have become especially challenging problems in California's signature cropping systems, which are characterized by little or no crop rotation due to soil limitations such as long cropping cycles (orchards and vineyards) that have relatively few opportunities for mechanical weed control. Although large by specialty crop standards, the approximately 3 million acres devoted to orchard and vineyards in California is a small market for herbicide manufacturers; thus, herbicide options are somewhat limited. Combined, these factors have led to a high degree of selection pressure for herbicide-resistant weed biotypes as well as weed population shifts to naturally tolerant species (Hanson et al. 2013; Prather et al. 2000).

In orchards, herbicide resistance is a more recent development and is dominated by resistance to the broad-spectrum postemergence herbicides such as glyphosate. This herbicide is, by far, the most widely used herbicide in the state in perennial crop production systems, as well as in many roadsides, canal banks and residential and industrial areas. The first herbicide-resistant weed in orchard cropping systems was perennial ryegrass, *Lolium perenne* (now named *Festuca perennis spp. perenne*), reported in 1989 (Heap 2021).

The first case of glyphosate resistance in California was reported in a population of rigid ryegrass (*Lolium* rigidium) in 1998 (Simarmata and Penner 2008). However, most confirmed glyphosate resistant ryegrass populations have been identified as Italian ryegrass (*Lolium* multiflorum) (Sherwood and Jasieniuk 2009). Glyphosate-resistant ryegrasses have become widespread and are a major weed problem in orchards, vineyards and roadsides of northern California (Jasieniuk et al. 2008). Research indicated that resistance in ryegrass is not due to metabolism of the herbicide and is glyphosate resistance in these areas has been largely driven by decreases in grower use of other herbicides, especially those under increasing regulatory pressure because of pesticide contamination of ground or surface water. The use of glyphosate-based herbicide programs also increased when the patent on Roundup expired in 2000 and low-cost, generic glyphosate herbicides became readily available. Today, glyphosate accounts for over 60% of all herbicide-treated acreage in California orchard and vineyard systems (DPR 2020).

The Conyzas

Glyphosate-resistant horseweed, or mare's tail (*Conyza canadensis*), was reported in 2005 and is one of the dominant weeds in and around raisin and tree fruit production areas of the San Joaquin Valley, as well as on roadsides and canal banks in the region (Hanson et al. 2009; Hembree and Shrestha 2007; Shrestha, et al. 2010). The level of glyphosate resistance in horseweed is relatively low, and resistant plants are usually injured to some degree following glyphosate applications, which suggests that resistance is not due to an altered target enzyme. Genetic comparisons of horseweed accessions from around the state suggest that there have been multiple, independent origins of resistance in this species, rather than the spread of resistance from a single-source population (Okada et al. 2013). Hairy fleabane (*Conyza bonariensis*) populations resistant to glyphosate were first reported in 2007 in the central San Joaquin Valley (Shrestha, Hanson, Hembree 2008). Glyphosate resistance in hairy fleabane appears to be similar to resistance in horseweed in that (1) selection has occurred in response to similar management strategies in perennial crops and surrounding areas (Hembree and Shrestha 2007); (2) multiple origins of resistance are suspected (Okada et el. 2014); and (3) growth stage and environmental conditions affect the level of resistance (Moretti, Hanson et al. 2013; Shrestha et al. 2007). Then there was the discovery by Moretti, Hanson et al. (2013) that hairy fleabane was now just resistant to glyphosate but now has built up a resistance to paraquat. It has been suspected by southern California growers that the two *conyza* species (Photo 7), horseweed and hairy fleabane are in fact glyphosate resistance, however this has not been scientifically confirmed in a lab.

Photo 7: Young plants of horseweed, Conyza canadensis (left) and flaxleaf fleabane (hairy fleabane), Conyza bonariensis (right). (Photo Credit: Jack Kelly Clark)

Potential New Products?

Decades of effective chemical weed control have led to an increase number of herbicide-resistant weed biotype populations, with few new herbicides with different modes of action (MOA) to counter this trend and often no cost-effective alternatives to herbicides in specialty tree crops. Integrating old and new weed management technologies into more diverse IWM systems may be the key. The lack of new chemistries and slowing of the herbicide discovery pipeline is probably due to several factors, including drastic consolidations of the pesticide industry, a substantial devaluation of the non-glyphosate herbicide market after glyphosate-resistant crops were introduced, more stringent regulatory requirements for new products (the cost to get a new product to market is tremendous), and diminishing returns of discovery approaches (Westwood et. al. 2018). Meeting the world's requirements for food and fiber in the future given current weed control methods and climate change, is an overwhelming task. Prospects look discouraging without new herbicide MOAs or a coordinated strategy to manage and prevent herbicide-resistant weeds. Nevertheless, cultivation trends such as high density plantings (Photo 8) can work in favor for growers as the tree canopies can quickly shade out orchard floors, preventing most weeds from emerging, suggest that multiple paths exist for improving weed control that can be integrated with existing methods to create more sustainable weed management system.

Photo 8: Example of high-density planting on San Diego County, eventually the entire. Orchard floor will be shadowed from the tree canopies (Photo Credit: David Ross).

References

California Avocado Commission. 2021. The History of the California Avocado. https://californiaavocado.com/avocado101/the-history-of-california-avocados/#:~:text=Today%2C%20California%20is%20the%20leading,avocado%20producing%20counties%20in%20California Accessed (February 17, 2021).

Hanson B, Fisher A, Shrestha A, et al. 2013. Selection Pressure, Shifting Populations, and Herbicide Resistance and Tolerance. UC ANR Pub 8493. Oakland, CA. 6 p.

Hanson BD, Shrestha A, Shaner DL. 2009. Distribution of glyphosate-resistant horseweed (Conyza canadensis) and relationship to cropping systems in the Central Valley of California. Weed Sci 57:48–53.

Hanson, B., Wright, S., Sosnoskie, L., Fischer, A., Jasieniuk, M., Roncoroni, J., Hembree, K., Orloff, S., Shrestha, A. and Al-Khatib, K., 2014. Maintaining long-term management: herbicide-resistant weeds challenge some signature cropping systems. California Agriculture, 68(4), pp.142-152.

Heap I. 2021. The International Survey of Herbicide Resistant Weeds. www.weedscience.com (accessed February 12, 2021).

Hembree K, Shrestha A. 2007. Control of glyphosate resistant marestail and hairy fleabane in orchards and vineyards. California Weed Science Society Proc 59:113–7

Holt JS, Stemler AJ, Radosevich SR. 1981. Differential light responses of photosynthesis by triazine-resistant and triazine-susceptible Senecio vulgaris biotypes. Plant Physiol 67:744–8.

Jasieniuk M, Ahmad R, Sherwood AM, et al. 2008. Glyphosate-resistant Italian ryegrass (Lolium multiflorum) in California: Distribution, response to glyphosate, and molecular evidence for an altered target enzyme. Weed Sci 56:496–502.

Katovich, J., Becker, R., and Doll, J. 2005. Weed seed survival in livestock systems. East Madison, WI: University of Minnesota Extension Service and University of Wisconsin Cooperative Extension, 1-6.

Lawes, R. A, Wallace J.F. 2008. Monitoring an invasive perennial at the landscape scale with remote sensing. Ecol. Manage Restor., v. 9, n. 1, p. 53-59, 2008.

Merriam Webster Dictionary. 2021. https://www.merriam-webster.com/dictionary/weed (accessed February 10, 2021).

Moretti ML, Garcia AM, Fischer AJ, Hanson BD. 2013. Distribution of glyphosate-resistant junglerice (Echinochloa colona) in perennial crops of the Central Valley of California. Proc Western Soc Weed Sci 66:19.

Moretti ML, Hanson BD, Hembree KJ, Shrestha A. 2013. Glyphosate resistance is more variable than paraquat resistance in a multiple-resistant hairy fleabane (Conyza bonariensis) population. Weed Sci 61:396–402.

Oerke, E.C. 2006. Crop losses to pests. J. Agric. Sci., v. 144, n. 1, p. 31-43, 2006.

Prather TS, DiTomaso JM, Holt JS. 2000. Herbicide resistance: Definitions and management strategies. UC ANR Pub 8012. Oakland, CA. 12 p.

Sherwood AM, Jasieniuk M. 2009. Molecular identification of weedy glyphosate-resistant Lolium (Poaceae) in California. Weed Res 49:354–64.

Simarmata M, Penner D. 2008. The basis for glyphosate resistance in rigid ryegrass (Lolium rigidum) from California. Weed Sci 56:181–8.

Shrestha A, Hanson BD, Fidelibus MW, Alcorta M. 2010. Growth, phenology, and intraspecific competition between glyphosate-resistant and glyphosate-susceptible horseweeds (Conyza canadensis) in the San Joaquin Valley of California. Weed Sci 58:147–53.

Shrestha A, Hembree KJ, Va N. 2007. Growth stage influences level of resistance in glyphosate-resistant horseweed. Calif Agr 61:67–70.

Takele, E. Stewart, D., Summer D. 2020. Avocado Establishment and Production Costs and Profitability Analysis in High Density Planting, San Diego County-2020. University of California Cooperative Extension. https://coststudyfiles.ucdavis.edu/uploads/cs_public/b4/3d/b43d58d9-1e91-4a3e-80f9-a2edb14958b0/2020avocadohighdensitysandiegocounty.pdf (Accessed February 11, 2021)

Washington State University, Agriculture. 2021. https://extension.wsu.edu/chelan-douglas/agriculture/treefruit/pestmanagement/weedcontrolplots/ (accessed February 10, 2021).

Westwood, J. H., Raghavan C., Stephen O. D, Fennimore, S., Marrone P., Slaughter, Clarence, D. Swanton, and Zollinger R. 2018. "Weed management in 2050: Perspectives on the future of weed science." Weed science 66, no. 3: 275-285.

Optimizing Salt Leaching

Ben Faber, Ventura/Santa Barbara Advisor

With little rain this winter and the erratic weather patterns of wind and heat, avocado is going to be especially prone to salt damage. And the flowering period is one of the most sensitive. Flowers are competing with leaves that have been hanging on for a year and have been salt stressed by a year's worth of irrigation salts. A good understanding of how salt moves and is leached it important to get through til next winter when there will hopefully be sufficient rain again to naturally leach the soil.

Water moves in a wetting front. When irrigation water hits the soil, it moves down with the pull of gravity and to the side according to the pull of soil particles (more lateral with more clay). Soil is a jumble of different sized soil particles, from clay to silt to sand sizes and then often intermixed with stones of different sizes from gravels to boulder. The different textures determine how water moves. It moves fastest through coarse textures and slowest through finer ones – the clays, the ones with the smallest pores. But soils are a jumble of particle sizes and pores.

Water first moves down the larger pores and then it slowly moves through the smaller ones. As water moves through the soil, it carries salts that have accumulated in the soil. At the wetting front is where the salt accumulates. As the water moves through the larger pores, salts migrate/diffuse from the small pores to the larger ones. This diffusion takes a bit of time, so typically the small pores have a larger salt concentration than the larger ones.

So an initial application of water will carry the salts from these large pores and if the irrigator were to stop in mid-application, it allows time for the salts to move out of the small pores into the larger ones. Then when the irrigation recommences, it will carry more of the salts out of the wetted area – the root zone. This technique is called "bumping" where an irrigation is stopped and then restarted in order to improve not only leaching, but also reduce runoff.

This principle also is at play when there are two or more sources of water quality. Soil salinity can be no lower than the irrigation water that is applied. Then as the soil, water is removed through plant absorption or evaporation, the salinity increases. The soil salinity can easily be two to three times higher than the irrigation water.

If there are two sources of water, the initial application can be with the poorer quality water, and once that has reduced the soil salinity, then the better water quality can be applied which will then bring the soil salinity closer to that of the better quality water. By doing this two part leaching, the amount applied of the better quality water can be significantly reduced. This is a type of "bumping" to improve leaching.

Watch this U-Tube video on how water moves through soil, thanks to the work at Walla Walla Community College.

https://www.youtube.com/watch?feature=player_detailpage&v=J729VzBeI_g

Topics in Subtropics

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