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Best Management Practices in Avocado Orchard Management

History of Federal Regulation of Water Quality

Water quality regulations in the United States began in 1948 with the induction of the Federal Water Pollution Control Act (WPCA). This policy, created and funded by the federal government, delegated responsibility of law development and implementation to each state (Houck, 1999). Since its creation, many amendments have been added which have resulted in major changes to the original WPCA. By 1960, the federal government realized that focusing only on “point” sources of pollution was not enough since surface and groundwater sources were still impaired. Therefore, in 1972, the WPCA was amended again with Section 303(d), which pointed toward regulations for water quality standards from both “non-point” in addition to point source polluters. This amendment also resulted in the renaming of the WPCA to the Clean Water Act (CWA). This act now has two major programs: (1) The Total Maximum Daily Loads (TMDLs), a set of narrative recommendations, amended in 2010 to numerical values, that define how much of a specific pollutant a water body can receive on a daily basis without compromising water quality; and (2) The National Pollutant

Discharge Elimination System (NPDES), which requires point-source polluters to mitigate effluent to meet specific water quality standards. Point-source pollution is defined as ‘discernible, confined, and discrete conveyance’. Under the CWA §303(d), states are to: (1) identify the water sources that are polluted; (2) establish the TMDLs that will restore water quality; and (3) allocate pollutant loads to discharge sources via state water programs and discharge permits. In order to oversee these programs the EPA divided the continental U.S. and associated territories into ten regions (<http://www.epa.gov/ceppo/sta-loc.htm>), each having an office which is responsible for assisting in the implementation and enforcement of water quality policies. California, Nevada, Arizona and Hawaii make up Region 9. In 1987, the CWA released the §319 Non-point Source Management Program. This addressed the need for more federal guidance to help states focus on non-point sources of pollution. In addition, federal grants provided financial assistance to states, territories and tribes for educational programs, demonstration projects and water quality monitoring.

California Water Quality Regulation

Because of the large geographical size and the diverse industries in California, potential pollution sources differ throughout the state. For example, many nurseries and dairies operate in southern California; therefore, nitrates and phosphates are major pollutants in this area. In northern California, excess deposition of sediments into waterways is a concern due to erosion caused by the logging industry. In addition, major differences in climate, especially rainfall also complicate water quality issues. To confront this problem and other issues, the State Water Resources Control Board (SWRCB) has divided the state into nine regions (Fig. 1), each housing its own Regional Water Quality Control Board (RWQCB). Under the direction of the SWRCB, each region is to develop regulations to mitigate pollution from impaired water bodies and because climate and industries differ vastly throughout the state, water quality regulations are usually different among the nine RWQCBs, as well as among different watersheds within a RWQCB.

Over the past decade, grants have been awarded to the University of California and other agencies to assist all growers in meeting the water quality objectives of the state and eliminate water impairments. Mitigation through Best Management Practices (BMPs) is one of the

highest priorities in the Los Angeles RWQCB Basin Plan. While BMPs have been established for all types of agriculture, this article will explain the BMPs that have been utilized for orchard management only.



Figure 1. Map of California, USA, showing the boundaries of the state's nine Regional Water Quality Control Boards (RWQCB). Water quality regulations are overseen by the State Water Quality Resources Control Board (SWQRCB) which delegates the responsibility for the development and implementation of regional basin plans to the nine RWQCB. Map Courtesy of State of California, 2000, California Environmental Protection Agency, State Water Resources Control Board. <http://www.swrcb.ca.gov/regions.html>.

Best Management Practices for Avocado Production

The primary objectives of BMPs are to 1) increase efficiency in the use of natural resources such as water, 2) mitigate pollution from runoff water, and 3) improve crop production efficiency to reduce costs. One of the most effective ways to mitigate pollutants from entering waterways is to minimize runoff from production sites. Any nutrients or

pesticides dissolved in irrigation water can enter waterways. Nitrate and phosphates are the primary nutrients of concern. Once a stream or river is enriched with these nutrients, algal blooms can cause anaerobic conditions. Dissolved pesticides can also impair water quality and be detrimental to native flora and fauna. The different types of BMPs can be divided into six categories that will be discussed below.

- Irrigation Management
- Nutrient Management
- Pest Management
- Salinity Management and Leaching
- Property Management
- Sediment and Erosion Management

Irrigation Management

The best methods of irrigation management will minimize water usage, since the overall goal is to direct water to the tree root systems with minimal runoff and leaching past the root zone. Irrigation management options include:

Pressure regulation

Pressure regulators can be installed for the whole irrigation system, at the well head, at the riser and/or at the emitter. Pressure regulation is especially important on slopes, where pressure drops with an increase in elevation (Figs. 2 and 3). Water pressure is also critical to insure that emitters function properly, and work to maintain acceptable distribution uniformities



Figure 2. Pressure regulators and mulching. Pressure regulators provide consistent flows to all trees regardless of elevation.



Figure 3. Pressure regulator and shut-off valve on a drip system provides water delivery to each irrigation line, despite changes in elevation. Shut-off valves at each line provide additional control to water usage throughout the orchard.

Mulch

Mulching the ground will conserve moisture by reducing evaporation from soil surfaces (Fig. 4). In addition, mulching will reduce the incidence of weeds, which can compete with tree roots for moisture and nutrients. This is especially true for avocados, which have a shallow root system. Once tree canopies are established, orchards will maintain a proper mulch layer with the annual leaf drop.



Figure 4. Mature Avocados are ‘self mulching’ since the fallen leaves provide similar attributes to chipped mulch: reducing runoff and retaining moisture, thus minimizing irrigation frequency.

Micro Irrigation

Converting from overhead to drip or micro sprayer irrigation optimizes the control and placement of water in the orchard to only tree roots (Fig. 5).



Figure 5. Microsprinkler systems provide water more precisely to the root system and minimize erosion potential.

Soil moisture monitoring

By measuring soil moisture in the root zone, a grower can determine, rather than guess, when water needs to be applied to the trees (Fig. 6). In addition, the duration of the irrigation episode can be determined by the irrigation time required to wet the root zone.



Figure 6. Realtime tensiometric moisture measuring. By monitoring soil moisture in the root zone, irrigation can be applied when water is needed and stopped when moisture reaches the rootzone.

Weather monitoring

Monitoring current weather conditions and will provide information needed to increase efficiency of irrigation and fertilizer programs (Fig. 7).



Figure 7. Weather stations can be equipped to measure solar radiation, wind speed, rainfall, relative humidity and temperature. Some monitoring stations indicate when a problem has occurred with the irrigation system.

Nutrient Management

Optimizing fertilizer usage means providing the correct amount of essential plant nutrients when the plant has the ability to absorb nutrients. It is imperative that the physical and chemical characteristics of the soil are ideal, and tree roots and canopies are healthy, since all these parameters will influence the availability and ability of plants to absorb and utilize nutrients from fertilizers. Nutrient management encompasses:

Water source

The water source should be free of debris that may clog emitters. Filters may be necessary so that irrigation emitters do not become clogged (Fig. 8). If the water source is high in soluble salts, reverse osmosis may be necessary. High bicarbonates may be corrected with acidification of the water.



Figure 8. Filtration system on supply line improves back flush rates, and reduces water and electricity requirements.

Chemical and physical soil characteristics

Well drained soils with a suitable pH and electrical conductivity should be provided. Inadequate soil conditions can impair healthy root system development, which is essential for nutrient absorption. The soil

pH and EC will also influence the solubility and availability of nutrients from fertilizer. For example, at higher pH (above 6.5), many micro-nutrients will precipitate out of solution, making them unavailable for uptake.

Plant health

Determining nutrient status of the tree is needed to know how much and what kind of fertilizer is needed. If a tissue analysis indicates that nitrogen levels are adequate, adding extra nitrogen in fertilizer will not be beneficial. In fact, plants have a feedback mechanism, whereby a signal is sent to the roots which will reduce the ability of the roots to absorb nitrogen if tissue levels are adequate. Though plants can control nutrient absorption to a degree, too much nutrient absorption can still occur, which may limit growth or cause more vegetative growth at the expense of fruiting.

Fertilizer management

Fertilizer may be applied as a granular or in liquid form through the irrigation. If granular fertilizers are used, place in proximity to irrigation emitters. If fertigation is employed, use extra care that runoff does not occur and leaching does not occur past the root zone.

Pest Management

An Integrated Pest Management (IPM) program should be practiced so that the use of pesticides is limited. Pesticides that are very soluble are more likely to get into the watershed. However, some pesticides, like glyphosate, bind to the soil and are carried into the runoff water through sediment (erosion). BMPs associated with pest management programs include:

Use of an IPM program

Cultivar and rootstock selection

Choose cultivars and rootstocks that have greater tolerance or resistance to diseases and pests.

Cultural practices

Optimize horticultural practices such as pruning, fertilization and irrigation to improve plant health and minimize environmental conditions that are favorable to pests and diseases.

Infrastructure

Factors such as paved, mulched or gravel roads will minimize dust settling on trees in proximity to roadways. Consider variables for tree placement so that minimal inputs are needed. For example, avoid valley floors where cold air can accumulate and damage crops in winter and steep slopes where erosion may be difficult to control.

Pesticide storage

Store pesticides in approved structures with impermeable floors to eliminate leaching of pesticides into groundwater or surface water sources.

Salinity Management and Leaching

Avocado roots are sensitive to high salts. Proper control of excess salinity in the root zone is essential. Healthy, actively growing young roots are the primary regions of the root zone absorbing nutrients. Damaged root systems will impair the nutrient uptake capacity of the tree, increasing the likelihood nutrient runoff and leaching.

There are several infrastructure considerations when managing ones property that will minimize or eliminate runoff of nutrients, sediment and pesticides.

Paved roadways

Paved roadways will eliminate erosion of roads and allow vehicle traffic during the wet season (Figs 9 and 10). However, since paved roads are impervious to water, curbs and/or gutters which can carry water away from site without causing erosion are necessary.



Figure 9. Gravel road reduces dust damage to trees and soil loss through wind and erosion.



Figure 10. Paved roads eliminate dust generated by vehicular traffic and provides a protective conduit for runoff (note camber inside road with asphalt curb). Since the runoff is not flowing through a bare ditch, there will be no erosion.

Water recycling

If excess runoff is not avoidable, water recycling should be considered. Proper treatment for pathogens will be necessary.

Mulching

Mulching will reduce impact of water onto soil and will minimize erosion.

Covercrops

Covercrops between rows can absorb excess water and nutrients, which may otherwise runoff from fields (Fig 11).



Figure 11. Cover crops may consist of a single species or a mixture of grasses, legumes, and/or forbs and are used to prevent soil erosion by runoff and wind.

Concrete Pads

Impervious concrete pads (Fig 12) should be utilized for equipment storage and maintenance so that oil and other fluids do not percolate into the groundwater.



Figure 12. Concrete Pad for Equipment provides a maintenance/storage area for tractors and farm equipment. This benefits the watershed as it provides a containment area reducing the potential for engine leaks and spill from percolating into the soil.

Critical Area Plantings

These plantings provide slope stability by absorbing water and providing anchorage of soil with the root systems. In some cases, “Critical Area Plantings” (Figs. 13 and 14) can contribute to plant pest control by following an Integrated Pest Management program.



Figure 13. ‘Critical Area Plantings’ consist of single species or a mixture of grasses, legumes, and/or forbs. These plantings provide slope stability and can contribute to plant pest control by following an Integrated Pest Management Program.



Figure 14. ‘Critical Area Planting’ with jute netting below. Jute netting helps retain the soil on the slope while the plants are becoming established. Once plants are established, the netting is biodegradable and turns into organic matter in the soil.

Sediment Containment

Sediment basins capture soil that would otherwise flow into the watershed (Fig. 15).



Figure 15. Sediment basin captures soil that would otherwise flow into the watershed. This grower has mulch, cover crops and ‘critical area plantings’. The vegetative buffer of cover crops and critical area plantings also absorb nutrients from water.

Contoured plantings

Contoured orchard rows (Fig. 16) reduce runoff on slopes and provides more uniform distribution of irrigation and easier management of irrigation lines.



Figure 16. Terracing an avocado orchard with the contour of the hillside will direct water runoff along contours rather directly down the slope which flow direction, slowing runoff and resulting in less erosion. Terraces are angled into the hillside to control the conveyance of water.

Windrows

Shelterbelts planted on the windward side of the orchards will reduce wind damage to orchard (Fig. 17) trees and reduce dust settling on tree canopies.



Figure 17. Tree windbreaks will reduce soil loss and dust accumulation on trees and reduce wind damage to orchard trees.

Sediment and Erosion Management

Certain pesticides bind to soil. Therefore, erosion and sediment ends up in runoff water from the orchard, and if soils leaves the site, there is a chance that pesticides will be carried offsite.

Mulch

Mulch is one of the most beneficial practices for avocado orchard management, since most crops are on slopes. Mulch will minimize erosion caused by rains and irrigation.

Drainage Ditch Improvements

Graveled, lined, or planted drainage ditches, stream banks and slopes will also decrease runoff (Figs 18, 19 and 20). Consider maintenance requirements and safety issues when designing and installing drainage channels and slope reinforcements. Occasional dredging, mowing may be required.



Figure 18. Grassed waterways can be composed of various grasses. Roots hold the soil in place, maintaining the channel grade and reducing runoff and soil loss.



Figure 19. Streambank stabilization protects the slopes from eroding in the rainy season. Often vegetation consists of willows, mulefat and other native vegetation.



Figure 20. Rock riprap reinforces the toe of the slope helping slow down rain runoff and keeping the soil on the slopes.

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