Almonds Peaches Prunes Almonds

Orchard Practices for Protecting Surface Water

Water Steward

SACRAMENTO & FEATHER RIVERS

Almonds Peaches Prunes Almonds

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*May be eligible for Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) funding. Check with your local NRCS office for specific information.

Orchard Practices for Protecting Surface Water

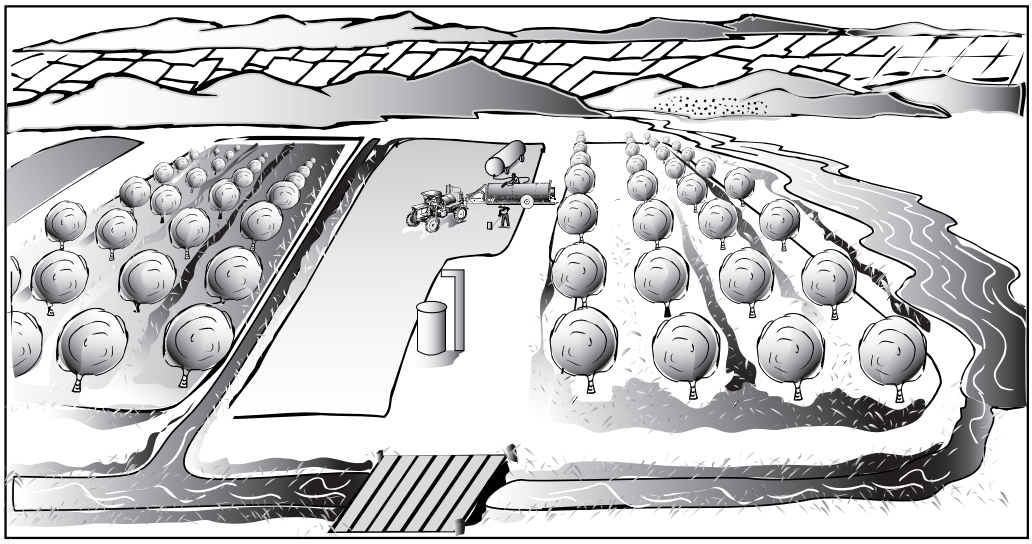
This booklet is a guide to orchard management practices that show potential for reducing pesticide runoff from orchards following dormant season applications. Some are proven techniques demonstrated to be effective in California agriculture while others are currently being studied. On any given farm site, some practices may perform as intended while others could be limited in effectiveness and practicality by crop, land gradient, soil types, local cropping patterns, and pest populations.

Orchard practices for protecting surface water fall into three categories:

PEST MANAGEMENT STRATEGIES.
ON-SITE PRACTICES FOR RUNOFF REDUCTION.
APPLICATION TECHNOLOGY (covered in separate publication).

Information in this document does not constitute a recommendation of any product or practice by the CALFED Bay-Delta Program or any county or state agency, including the California Department of Pesticide Regulation (DPR) or the Central Valley Regional Water Quality Control Board.

In some cases, trade names of products have been used. No endorsement of these products is intended, nor is criticism implied of similar products that are not mentioned. With all pesticide applications, carefully read and follow label directions to determine the legality of a specific use.



Pest Management Strategies

The peach twig borer, San Jose scale, and various aphid and mite species are serious economic pests of almonds and stone fruits in California and are typically controlled by dormant applications of oil and OP (organophosphate) pesticides such as diazinon, Supracide or Imidan. From a pest management perspective, the best time for OP pesticide applications is during the dormant season. Dormant applications were originally recommended, in part, to help reduce environmental impacts, damage to pollinators and predator insects and reduce in-season worker exposure and pesticide applications. However, OP pesticide applications during the rainy dormant season carry certain environmental risks. OP pesticides are routinely detected in the Sacramento and Feather Rivers following dormant spray applications during and after mid-winter storms.

Viable alternative strategies to OP pesticides are those which offer favorable levels of pest control efficacy, are effective in reducing the risk of aquatic toxicity and are comparable in cost to conventional OP pesticide dormant sprays. A viable strategy could also be used for OP pesticides with proper mitigation measures in place that prevent offsite movement. Viable pest management strategies do exist that can reduce or even eliminate the amount of OP pesticides applied during the dormant season.

It's important to note that any pest management practice, including dormant OP pesticide applications, should include close monitoring of orchard pest populations for success. The cost of pest monitoring can vary but may increase the overall cost of pest control by $20 an acre, based on University of California research. However, savings in pesticide costs may offset the cost of pest monitoring.

Strategy 1

Dormant Diazinon and Oil Spray

When using diazinon, use appropriate on-site practices and application methods to reduce potential for off-site movement. Each orchard has a range of potential contributions to runoff and associated aquatic toxicity based on orchard site characteristics (soil type, slope, proximity to water bodies, etc.).

Considerations

- Diazinon applications are frequently alternated with non-OP pesticides to prevent resistance from developing to either diazinon or non-OP pesticides.
- Information is being developed on earlier timing of winter OP applications when less rainfall is likely or when the rainfall is more likely to be absorbed into the soil rather than runoff.
- Reduced rates: additional data is needed to demonstrate effects at varying pest (aphid) densities.

Strategy 2

No Dormant Treatment or Dormant Oil Only Treatment

Dormant insecticide spray is not applied or an oil only treatment is made.

Considerations

- Additional in-season treatments for mites may be necessary following in-season applications of carbaryl, esfenvalerate and permethrin for peach twig borer (PTB) in peaches and nectarines.
- Additional spring treatments may be necessary for aphids in plums and prunes.
- Skipping dormant insecticide sprays has been successful in plums and prunes when pest pressure is low or non-existent.

Strategy 3

Alternate Year Dormant OP Pesticide With Yearly Oil Spray

Considerations

- Lower rates may be used if San Jose scale is not present.

Years with No Dormant Sprays

Considerations

- Additional in-season treatments for peach twig borer in peaches and nectarines may be necessary.
- Additional in-season treatments for mites following in-season applications of carbaryl, esfenvalerate and permethrin for PTB in peaches and nectarines may be necessary.
- Additional spring treatment for aphids in plums and prunes may be necessary.
- Monitor for presence of San Jose scale

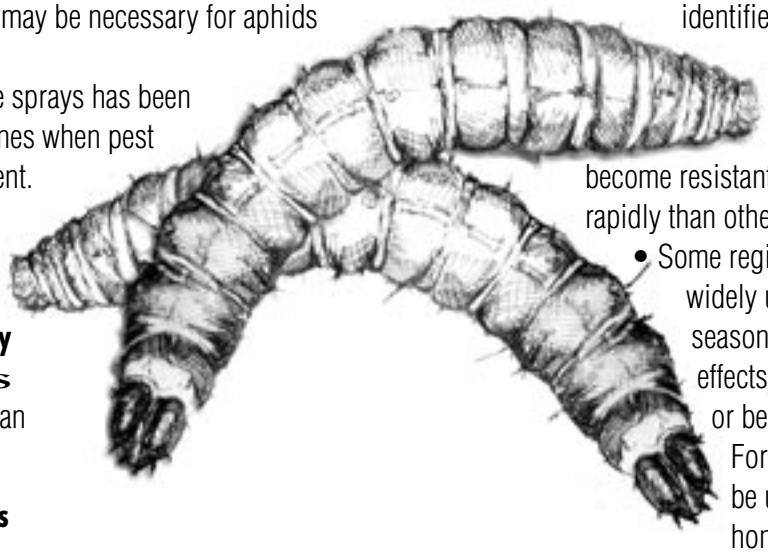
Strategy 4

Dormant Spray (Non-OP Pesticides) and Oil

Pyrethroids (permethrin and esfenvalerate) and carbamates (carbaryl) for peach twig borer in the delayed-dormant or dormant season.

Considerations

- Pyrethroids are not as effective as an OP pesticide and oil spray for controlling San Jose scale during the dormant season. OP pesticides should be considered if dormant spur monitoring indicates moderate to high San Jose scale populations.
- Residues of the pyrethroid insecticides permethrin and esfenvalerate persist on bark and may impact naturally occurring predator mites for extended periods of time after dormant season and in-season applications.
- Mite outbreaks caused by use of pyrethroids may require additional miticide treatments over and above those normally applied.
- While pyrethroids remain effective for controlling peach twig borers in most areas, greatly increased tolerance by Oriental fruit moth (OFM) to pyrethroids has been identified in the Sacramento Valley, raising the possibility of resistance.
- In general, insects become resistant to pyrethroids more rapidly than other classes of pesticides.
- Some registered products are not widely used in the dormant season because of possible effects on non-target organisms or because of label restrictions. For example, carbaryl cannot be used in orchards where honeybees are present and endosulfan use is restricted near water or wetlands.
- Non-OP pesticides can affect non-target organisms in water and the potential for offsite movement from runoff has not been well studied.



- If a non-OP pesticide is applied as a dormant spray, precautions such as on-site practices (following sections) should be taken to prevent movement into surface waters.
- Laboratory exposures indicate that fish and invertebrates are particularly sensitive to pyrethroids. Pyrethroid persistence may mean that they will be transported off site. If so, they may be bioavailable to fish in water or to invertebrates in sediment. Sediment toxicity may result after pyrethroids are transported into water bodies.

Crop-Specific Considerations

- Nectarines and plums/prunes: Permethrin is not available for use.
- Plums: Synthetic pyrethroids are not labeled for use.

Strategy 5

Spinosad and Oil as Dormant Spray

Spinosad (Success Naturalyte insect control) is a low-risk pesticide for control of peach twig borer. However, it is not effective for San Jose scale or aphids.

Considerations

- Dormant prunings should be examined to determine if San Jose scale populations require treatment.
- Peach twig borer shoot strikes should be monitored in each generation as well as the presence of larvae as fruit starts to ripen. If monitoring indicates that any of the pest species require additional control measures, they can be applied in-season.
- Additional in-season treatments for peach twig borer in peaches and nectarines may be necessary.

Strategy 6

Bloomtime Sprays of Bacillus thuringiensis (Bt) For Peach Twig Borer.

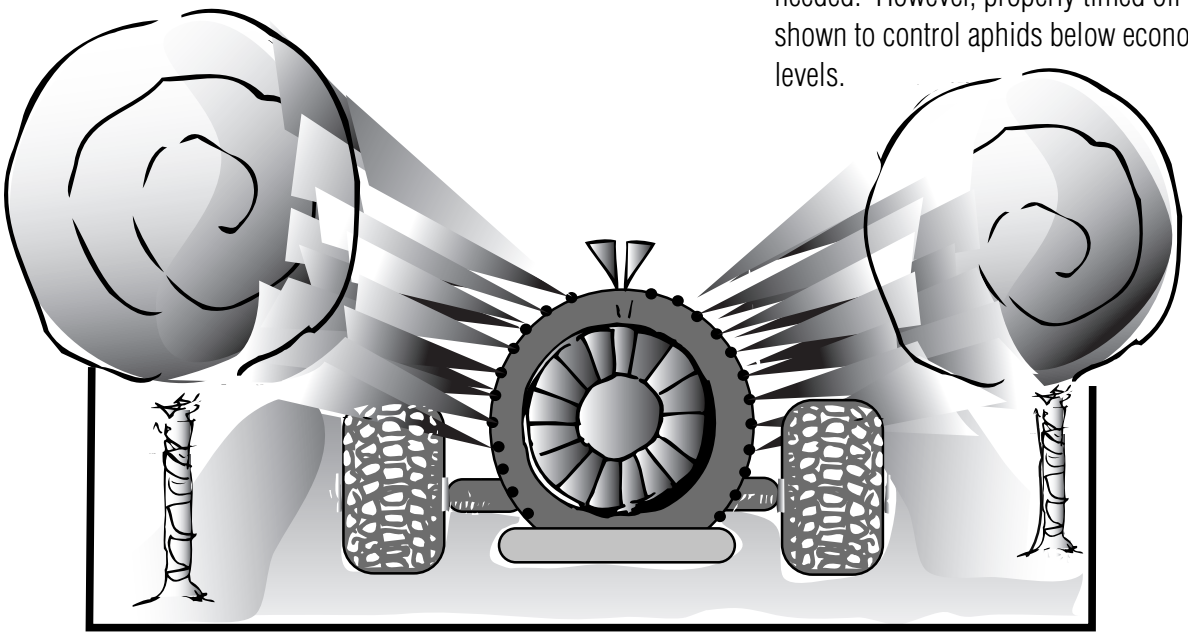
Treatments of Bt at bloom (almond, peach, plum, prune) to control over-wintering peach twig borer larvae.

Considerations

- This strain of Bt only effects larvae of butterflies and moths and is not considered harmful to humans, pest parasites, predators or aquatic species.
- Bt will not control aphids or San Jose scale.
- Two treatments are often necessary in peach and nectarine orchards.
- Dormant prunings should be examined to determine if San Jose scale populations require treatment.
- Peach twig borer shoot strikes should be monitored in each generation, as well as the presence of larvae as fruit start to ripen. If monitoring indicates that any of the pest species require additional control measures, treatments can be applied in-season.
- Additional spring treatment options for aphids in plums and prunes may be necessary.

Crop-Specific Considerations

- Peaches and nectarines: A dormant oil and Bt program may not control peach twig borer to below economic levels. Additional in-season treatments may be needed.
- Plums and prunes: Oil applied alone during the dormant or delayed dormant season, as part of a Bt program, provides no control of leaf curl plum aphid and mealy plum aphid. Additional in-season treatments may be needed. However, properly timed oil sprays have been shown to control aphids below economically damaging levels.



- This strategy works well in peaches where dormant oil is used for control of San Jose scale.

Strategy 7

Pheromone Mating Disruption for Peach Twig Borer

Mating disruption relies on releasing pheromones through dispensers distributed throughout an orchard or applied as a spray. It has been shown to be effective against peach twig borer in almond, peach and nectarine orchards (although some details of application and effective rates of specific products are incomplete). Pheromone mating disruption cannot be considered a stand-alone system. It is selective for the target pest so monitoring for other orchard pests as well as peach twig borer is necessary.

Considerations

- Pheromone mating disruption is most effective in orchards with low moth populations and orchards that are not close to other untreated peach twig borer hosts, which can be sources of mated females.
- Mating disruption is most effective when used on an area-wide basis where all growers in an area adopt the practice.
- Factors that reduce efficacy of pheromone mating disruption include small orchard size, uneven terrain, windy sites, reduced pheromone application rates and improper treatment timing.
- Cost of the material and its application are high relative to pesticide treatments.
- The application cost of mating disruption for peach twig borer can be reduced in peaches and nectarines if pheromone dispensers are applied at the same time as mating disruption for the oriental fruit moth.
- Dormant prunings should be examined to determine if scale populations require treatment.
- Peach twig borer shoot strikes should also be monitored in each generation, as well as the presence of larvae as fruit start to ripen.
- If pest monitoring indicates that any of the pest species require additional control measures, they can be applied during the season. Oil sprays alone applied during the dormant season will provide control of European red mite, brown mite, and low populations of San Jose scale, but will have minimal impact on overwintering peach twig borer larvae.

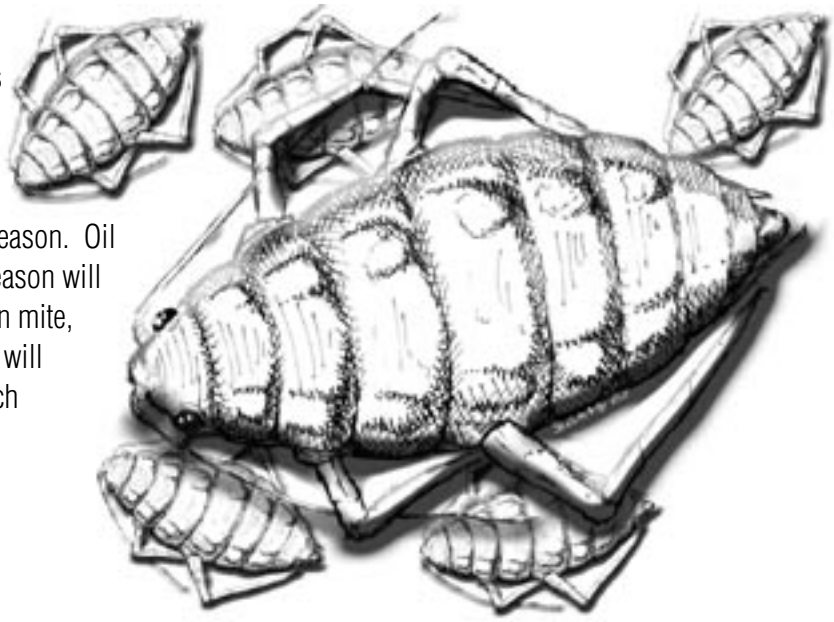
Early Dormant OP Application

Researchers at the University of California are studying the potential of applying dormant OP sprays in mid-December. The hypothesis is that applying OP pesticides earlier will allow more soil infiltration of rainfall and dissolved pesticides when early rainfall occurs prior to the ground becoming saturated. Results from one year of study (Zalom et al 2001) suggest no significant difference in the efficacy of mid-December, early January and late January treatments in controlling peach twig borer and San Jose scale on almonds in the San Joaquin Valley.

Applying dormant sprays earlier increases the potential for phytotoxicity from spray oils should trees be water-stressed. Further study is needed to evaluate possible factors influencing phytotoxicity and its occurrence in trees, particularly prunes.

Cost Information on Strategies

To access an online calculator to compare costs for these and other pest management strategies, see the University of California Integrated Pest Management website at http://ipm.ucdavis.edu/WATER/OPCALC/. Additional information is available at http://ipm.ucdavis.edu/.



On-Site Practices for Runoff Reduction

On-site practices are approaches for managing soil, water, pesticides and nutrients for sustainable agricultural production while minimizing environmental impacts.

The goal of on-site practices is to:

- Reduce or eliminate sediment movement off the orchard site.
- Reduce or eliminate flows of runoff water carrying dissolved pesticides and nutrients.

Orchard Floor Vegetation During Dormant Season

This can be seeded or resident vegetation growing on orchard floors that is later mowed or disked.

Types of vegetation

Resident vegetation. The existing, unplanted mixture of annual or perennial weeds, crop species and/or native grasses and forbs which has adapted to management methods used in the orchard. Resident vegetation has been shown to be as effective as seeded cover crops at increasing water infiltration and reducing offsite movement of pesticides.

Seeded cover crops. Includes many types of cultivated species including legumes (bell beans, peas, clover, medics and vetches) and grasses such as cereal grains, turf grasses and sudan grass. Seeded cover crops are sown but not harvested plants or mixtures of plants that can add fertility and tilth to the soil, fix atmospheric nitrogen, reduce erosion, suppress weeds, trap and recycle excess soil nitrates and provide other specific management benefits for the planted crop.

Orchard floor vegetation can reduce dormant spray pesticide runoff to surface waters in several ways:

- Reduction in runoff volume through increased water infiltration.
- Reduction in sheet erosion caused by rainfall impact on bare ground.
- Decrease in pesticide mass carried by sediment.
- Shorter pesticide persistence (faster breakdown) on vegetation than soil.
- Adsorption of pesticides to plant surfaces.

Benefits

- Anchors soil during winter rains preventing soil, nutrient and pesticide runoff.
- Allows pesticides to break down and be filtered onsite.
- Adds organic material to the soil.
- Accelerates the biodegradation of pesticides in soil.
- Can reduce plant parasitic nematodes by antagonism.
- Legume cover crops fix atmospheric nitrogen and release it to the orchard crop during the growing season.
- Improves water infiltration, soil aeration and soil texture.
- Improves soil fertility.
- Assists in weed control (seeded covers).
- Improves orchard access during wet weather.
- Cover crops provide nectar sources, pollen and prey for beneficial predators.
- Stone fruit orchards (apricots, cherries, peaches, plums) can support a full perennial sod of grasses or clover. Approximately 6% of California dried plum acreage contains permanent sod cover crops.

Drawbacks

- Increased cover and feed for gophers, ground squirrels and mice (also higher populations from increased habitat and reduced predation).
- Increased humidity can potentially create conditions for fungal diseases.
- Potentially increased nematode populations with summer-grown cover crop.

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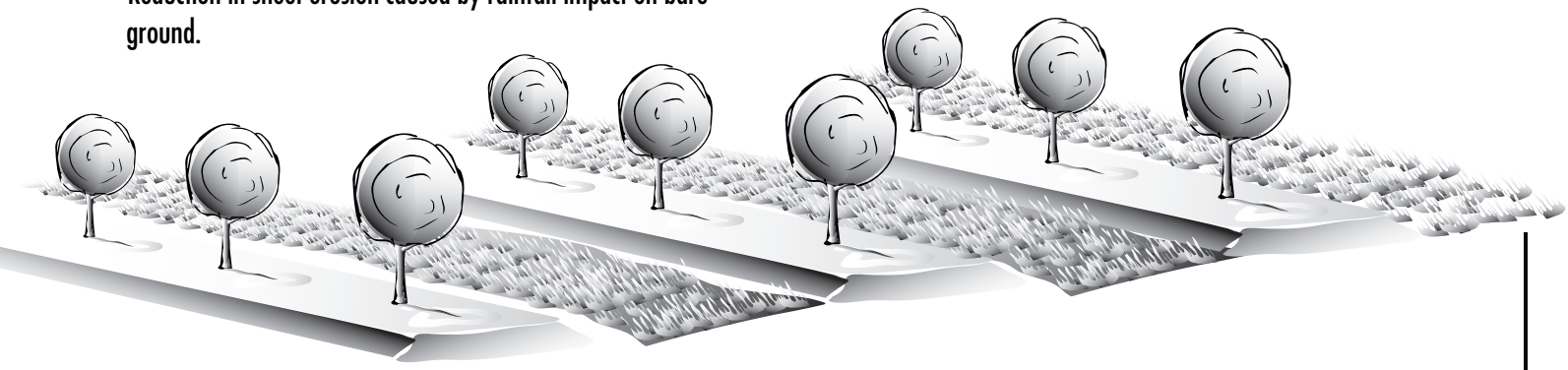


- Higher water use with perennial cover crops.
- Sprinklers can be blocked by climbing vetches.
- Blooming cover crops can compete with tree crops for pollinator insects if not mowed.
- Increased danger of frost damage. A tall, dense cover crop can reduce orchard temperatures by to 2 to 6 degrees, increasing the potential for frost damage. However, orchards with closely mowed cover crops and moist soil may be only about 1 degree colder than bare soil. Alternate row cover cropping can reduce the difference even more. Mowing before frost reduces the risk of frost damage.
- Trash (plant residue, particularly grasses) at harvest can hinder almond pick-up. However, growing an annual legume cover crop mix that can be mowed and allowed to decompose over summer causes fewer harvest problems.

Resident Vegetation

Unplanted mixture of annual or perennial weeds, crop species and/or native grasses and forbs.

Benefits

- Can be easily encouraged to grow in the fall or early winter by a post harvest irrigation or early rains.
- Requires little to no management to establish.

Drawbacks

- Can be difficult to manage if noxious weeds are present.
- Requires mechanical or herbicide control in late winter or early spring if overgrown.

Seeded Cover Crops

Annuals

Large-seeded winter-annual cover crops (also called green manures) include monocultures or mixtures of:

- Cereal grains (oat, barley, cereal rye, triticale)
- Legumes (vetches, bell bean, field pea)

Small-seeded winter-annual cover crops include monocultures or mixtures of:

- Soft chess (Blando bromegrass)
- Foxtail fescue (Zorro fescue)
- Medics (burr medic, barrel medic)
- Clovers (crimson clover, Persian clover, rose clover and subterranean clover)

Perennials

Perennials are most suited for stone fruit orchards. In almonds, perennials may interfere with harvest.

- Small-seeded, low-stature, non-native grasses and legumes
- Creeping red fescue
- Dwarf turf fescue
- Chewings fescue
- Perennial ryegrass
- Sheep fescue
- White clover
- Idaho fescue
- Pine bluegrass

Cover Crop Management

Cover and Green Manure Crop

Plants are disked to incorporate organic material and improve soil fertility and tilth. Disking (or mowing) is generally done when plants are in full-bloom to post-bloom stage, depending on frost potential and soil moisture conditions.

Mowed Cover Crop

Managed by mowing to maintain at least 60% ground cover where erosion is possible. Mowing to 3-4 inches prior to frost can reduce cold temperature damage potential. Mowing intervals can often allow adequate seed production for following season re-growth. Mowed cover crops reduce dust during harvest operations and improve water infiltration rates.

Disked Cover Crop

Plants typically disked at full-bloom to post-bloom stage, depending on condition of the target crop, weather and soil moisture conditions. Maintain at least 60% ground cover where erosion is possible. Mowing to 3-4 inches prior to frost can reduce potential for cold temperature damage.

Vegetative Buffers

Areas or strips of land surrounding an orchard that are maintained in permanent vegetation. To effectively trap pesticides, buffers must slow water runoff and increase infiltration so that pesticides can be trapped and degraded in buffer soil and vegetation. Vegetative buffers are a tool to further improve water quality and provide additional benefits such as wildlife habitat and stream bank protection. For best success, they should be used in conjunction with other mitigation practices.

Benefits

- Can be used to manage soil, water, nutrients and pesticides while minimizing environmental impacts.
- Effective in trapping eroded sediment, reducing runoff of pesticides that are adsorbed to soil particles. Note: some pesticides (e.g. OPs) are highly water soluble and don't adsorb to soil particles as readily as others (e.g. pyrethroids).

Drawbacks

- California-based research is limited on the potential for orchard filter strips and grassed waterways to reduce OP pesticide loading, although the practices have been shown to be effective in other regions of the U.S.
- Uncertainties of buffers include: appropriate dimensions for volume of water flow; appropriate plant species and plant density for the soil types and rainfall zones; considerations for various locations; slope and channel dimensions for grassed waterways; and dimensions for constructed wetlands.
- Can require growers to set aside productive acreage.

Vegetative Filter Strips

Areas of grass or other permanent vegetation used to reduce sediment, organics, nutrients, pesticides and other contaminants in runoff to maintain or improve water quality. Vegetative filter strips are located between crop fields and water bodies, i.e. grassed roadways. Plant material captures rainfall and retains nutrients. Roadways can be grassed or sod planted, as can sprayer mixing pads and wellheads. Depending upon the site, a full border around an orchard may not be necessary for mitigating impacts to surface water. Filter strips could be planted at low ends of fields or in other critical zones.

Benefits

- Slows runoff allowing sediment to drop out of suspension.
- Traps sediment with adsorbed pesticide residues.
- Increases water infiltration into the soil profile.
- Catches some pesticide drift, preventing it from reaching the soil.

Drawbacks

- If water runoff is channeled, a grass strip may not effectively trap the adsorbed pesticides.

Vegetative Barriers

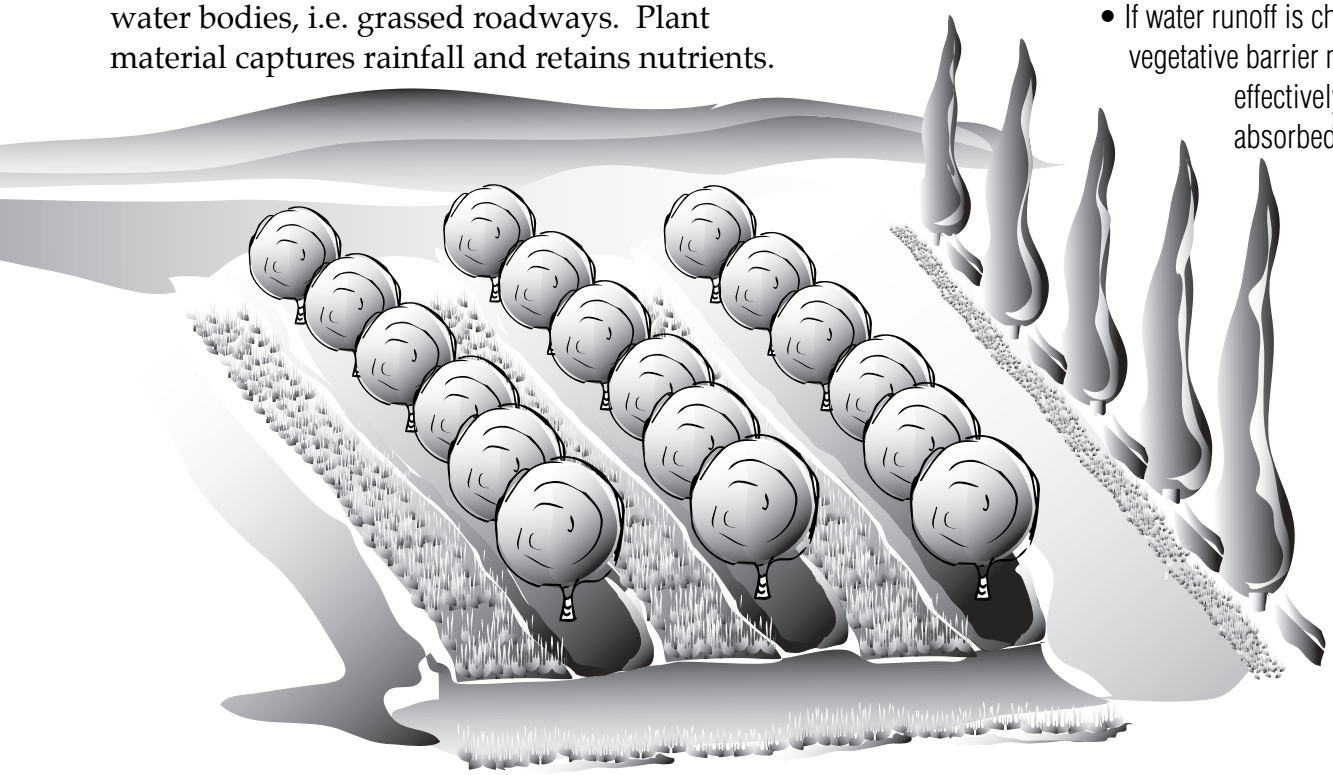
Narrow, permanent strips of stiff stemmed, erect, dense, perennial vegetation established in parallel rows and perpendicular to the dominant slope of the field.

Benefits

- Effective in dispersing concentrated flow, thus increasing sediment trapping and water infiltration.

Drawbacks

- If water runoff is channeled, a vegetative barrier may not effectively trap the absorbed pesticides.



Cover Crop Costs

Estimated costs for cover crops in 2001 and characteristics of species viable for Central California conditions.
Source: Fred Thomas, CERUS Consulting. Biological Prune Systems Project, 1999.

Item	lb/acre	$/acre	Stand Life (yrs)	Units of Nitrogen	Soil Improvement
Barley	120	23.00	1	0	++++
Oats	100	18.00	1	0	++++
Triticale	100	18.00	1	0	++++
Bell Beans	140	36.00	1	130	+++
Magnus Peas	60	27.00	1	130	++
Common Vetch	50	22.00	1	130	++
Lana Vetch	50	42.00	2-3	180	++
Purple Vetch	50	32.00	2	180	++
Berseem Clover	25	38.00	1	180	++
Crimson Clover	25	44.00	1-2	130	++
Burr Clover	20	40.00	5	100	++
Strawberry Clover	12	41.00	15	100	++++
N.Z. White Clover	12	32.00	15	100	+++
Broadleaf Trefoil	12	44.00	15	100	++++
Bermuda Grass	10	25.00	25	-30	0
Creeping Red Fescue	25	28.00	10	-30	+++
Dwarf Ryegrass	35	42.00	10	-30	+++
Sheeps Fescue	20	81.00	10	-15	++
Hard Fescue	20	68.00	10	-15	++
Organic Builder	100	39.00	1	60	+++++
All Legume Mix	100	51.00	1	160	+++
All Grass Sod	35	51.00	12	-30	++++
Grass/Clover Sod	35	61.00	12	0	++++
No-Till Clover	25	62.00	5	50	+++

Filter Strip Costs

Estimates for a 10-foot filter strip bordering a 160-acre orchard (about 2.5 acres of grasses).

Species	Seeding lb/ac	$/lb	$/ac	$/160 ac
Bermuda Grass	6	4.00	24.00	60.00
Orchard Grass	15	1.50	22.50	56.25
Blue Wild Rye	15	15.00	225.00	562.50
Creeping Wild Rye	12	30.00	360.00	900.00

Grassed Waterways

Natural or constructed channels planted in permanent vegetation and located in an area where runoff concentrates. Constructed waterways can be graded to carry surface water at a non-erosive velocity to a stable outlet. Waterways are most effective in trapping sediment and dissolved chemicals when designed to spread concentrated water flow evenly across a vegetative filter adjacent to waterways.

Benefits

- Helps slow the flow of water to a non-erosive level.
- Provides a means of trapping sediment, nutrients, and pesticides while preventing gully erosion.
- Provides habitat and cover for wildlife.

Drawbacks

- Storm flows can be restricted by overgrown channels causing waterway breaching and flooding.
- Due to the concentrated flow that normally occurs in waterways, sediment trapping and water infiltration can be minimal with large runoff events, but substantial with smaller events.

Riparian Buffers

Trees and shrubs planted adjacent to streams, lakes, ponds and wetlands. Forest buffers are frequently combined with an understory of perennial grass buffers.

Benefits

- Helps lower water temperatures by shading the water body.
- Protects stream banks and slows out-of-bank flood flows.
- Deep tree roots may intercept nitrate entering streams in shallow subsurface flow and provide soil carbon for microbial energy. Microbes can denitrify nitrate and degrade pesticides.
- Woody vegetation provides food and cover for wildlife.
- Contributes energy sources to aquatic communities.

Drawbacks

- If water runoff is channeled, riparian buffers may not effectively trap pesticides.

Constructed Wetlands

Wetlands constructed at tile outlets or as part of riparian buffer systems for degrading pesticides and denitrifying nitrates.

Benefits

- Provides confined area for breakdown of pesticides in water.

Drawbacks

- Land needed for constructed wetlands is not readily available in high production areas. Available land can be costly.

Hedgerows

Fences of shrubs or trees in, across, or around a field. Hedgerows can include an understory composed of perennial native grasses and forbs, a shrub midstory composed of California native species and occasionally a discontinuous overstory of valley and foothill trees.

Benefits

- May reduce erosion by having perennial vegetation on a portion of the field.
- If runoff flows across the hedgerow in sheet flow, sediment can be trapped, reducing the amount of sediment and sediment-borne pesticides from entering surface waters.
- Can attract beneficial insects and provide competition against invasive weeds.
- Windbreaks and hedgerows can provide drift mitigation, potentially reducing off-site movement of pesticides.
- Because many of the native species used in hedgerows have deep roots that hold the soil and increase water permeability, there may be a reduction in water runoff and off site movement of sediment. This could reduce runoff of pesticides in the dissolved and sediment-borne phases of field runoff. However, no studies have quantitatively measured the reductions in OP pesticide runoff.

Drawbacks

- Certain plant species may attract pests that can attack the crop or neighboring crops. Careful consideration must be given to the species of vegetation selected and the types of insects that may be attracted.
- Plant species can provide habitat and attract endangered species. Safe Harbor Agreements are available to protect growers where a practice is implemented that could attract endangered species to their farms, a factor that should be evaluated and addressed before establishing hedgerows.
- Some species can grow 10-15 feet wide, so space must be allowed for equipment to pass.

Hedgerow Costs

Estimated costs for installing and maintaining a hedgerow (15' x 1400' ; approx. 0.5 acres). Hedgerow planted with strips/rows of native grasses and shrubs (Source: *Bring Farm Edges Back to Life*; Yolo County Resource Conservation District, 4th Edition, 1999).

TASK	DATE	LABOR COST	MATERIAL COST	EQUIPMENT COST	TOTAL
Hedgerow Installation					
Hedgerow design	6-11/96	$260	Survey flags: $8.00		$268.00
Roundup: summer weed control	8/96	$20	Roundup: $30.00	ATV+ sprayer: $8.08	$58.08
Disc: pre-plant weed control	10/96	$10		Tractor + disc: $18.09	$28.09
Bed preparation	10/96	$10		Tractor + bedshaper: $14.33	$24.33
Fertilize — preplant (tablets)	11/96	$20	Fertilizer: $43.50		$63.50
Plant trees, shrubs and forbs	11/96	$120	Plants: $500.00		$620.00
Install 2 Tubex tree tubes	11/96	$50	Tubex: $172.50		$222.50
Plant grasses (broadcast)	11/96	$20	Seed: $275.00		$295.00
Harrow to cover grass seed	11/96	$10		ATV + harrow: $4.04	$14.04
Roundup: annual weed control	11/96	$10	Roundup: $15.00		$25.00
Ronstar-G: apply in plant row	11/96	$10	Ronstar-G: $75.00		$85.00
Install drip irrigation system	3/97	$100	Drip supplies: $200.00		$300.00
TOTAL INSTALLATION		**$640**	**$1,319**	**$44.54**	**$2,003.54**

TASK	DATE	LABOR COST	MATERIAL COST	EQUIPMENT COST	TOTAL
Hedgerow Maintenance, Year 1 & 2					
2,4-D: Broadleaf weed control	3/97	$10	2, 4-D: $20.00	ATV + sprayer: $4.04	$34.04
Hoe hedge plant row*	3-9/97	$250			$250.00
Irrigate 2X/month	3-10/97	$250	Emitters/plugs: $8.25		$258.25
Mow grasses: annual weed control	4/97	$10		Tractor + mower: $10.19	$20.19
Remove Tubex	4-5/97	$20			$20.00
Roundup: spot spray	5-6/97	$20	Roundup: $15.00		$35.00
Fertilize: preplant (tablets)	9/97	$10	Fertilizer: $8.75		$18.70
Replant trees, shrubs and forbs	9/97	$80	Plants: $100.00		$180.00
2,4-D: spot spray in grasses	9/97	$10	2,4-D: $10.00		$20.00
Flame: annual grass weed control	10/97	$10	Propane: $15.00	ATV + flamer: $4.04	$29.04
Ronstar-G: entire hedgerow	10/97	$20	Ronstar-G: $225.00		$245.00
Mow grasses 2X: weed control	3-5/98	$20		Tractor + mower: $20.38	$40.38
Hoe hedge plant row	3-5/98	$120			$120.00
Irrigate 2X/month	4-9/98	$200			$200.00
Hoe hedge plant row	6-7/98	$120			$120.00
Herbicide: 2,4-D (in grasses)	8/98	$10	2,4-D: $10.00		$20.00
TOTAL MAINTENANCE		**$1,160**	**$411.95**	**$38.65**	**$1,610.60**
TOTAL COST		**$1,800**	**$1,730.95**	**$83.19**	**$3,614.14**

*Ronstar-G applied in the plant row reduces hoeing cost by one-half compared to non-treated sites. Labor estimated at $10.00/hour.

Reducing or Eliminating the Herbicide-Sprayed Berm

Berm areas of orchards sprayed with herbicides represent a bare conduit for runoff of rainfall or irrigation water. By allowing vegetation to grow and reducing the berm width or seasonal spraying of the berm, runoff potential from an orchard could be reduced.

Management Options

- Reduce strip spray widths by 25%.
- Apply herbicide in January/February after sprouted grass covers the berm.
- Spray a 5-foot square block around trees to keep the trunk area clean but leave vegetation on the remainder of the row berm.
- Stop spraying herbicides at the next-to-the-last tree in each row, leaving a vegetative barrier surrounding the orchard.
- Eliminate use of pre-emergence herbicides.

Cost Savings

Cost savings are possible from reducing or eliminating the herbicide-sprayed berm. However, timing of clean-up herbicide treatments is important. Savings are also possible if herbicide-sprayed strip is narrowed.

- One less herbicide spray: approximately $12.00/acre.
- No herbicide sprays: approximately $48.00/acre.
- Spraying 5 by 5-foot block around trees: approximately $36.00/acre.

Benefits

- Reduction in runoff volume through increased soil infiltration.
- Decrease in soil erosion and movement of pesticides with soil borne runoff.
- Shorter pesticide persistence on vegetation than soil and better absorption on plant surfaces (faster degradation on plant matter). An orchard floor that is completely vegetated versus 25% bare soil has greater area for these mechanisms to function.

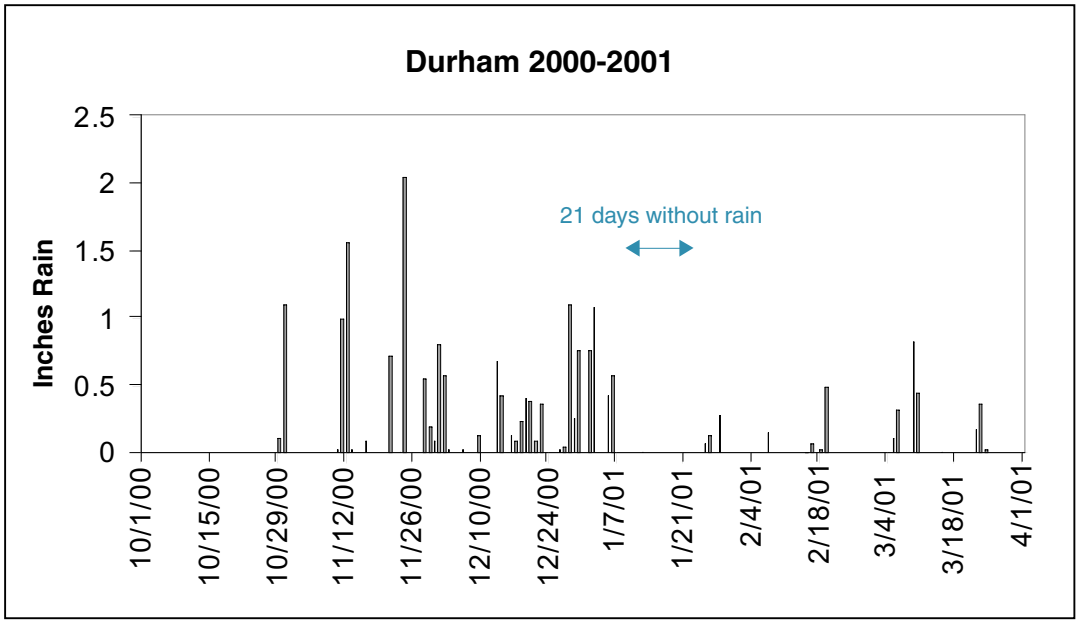
Drawbacks

- Vegetation on berms can be difficult to manage in almond orchards.
- Vegetation control can be difficult if excessive growth occurs before herbicide is applied.
- Constant use of a single herbicide may lead to weed resistance developing.

Winter "Dry Gap"

Analysis of rainfall patterns in the Central Valley over the last five years indicates that a "dry gap" of 10 to 21 days occurs almost every year between early December and late January. Weather forecasting has improved in recent years with several companies offering local predictions of upcoming rain events (www.fieldwise.com or www.foxweather.com). When possible, timing dormant orchards sprays to early in this dry gap can reduce the potential for pesticides to be carried by runoff from orchards.

Caution: Dry gaps can also coincide with foggy conditions when dormant spraying should be avoided.



Managing Runoff Water

Several on-site practices have been identified for managing field runoff water. While some offer potential, none have been studied in California to measure reduction of OP pesticide runoff.

Water and Sediment Control Basins

Constructed earth embankments or a combination ridge and channel. Constructed across the slope and minor watercourses to form a sediment trap and water detention basin.

Benefits

- Trap sediment and pesticides adsorbed to soil particles.
- Reduce and manage onsite and downstream runoff.
- Divert the flow of dissolved substances such as nutrients and pesticides.
- Improve the farmability of sloping land, reduce water course and gully erosion.
- Improve downstream water quality.

Drawbacks

- Basins are not viable for many orchard areas in California, primarily because considerable land acreage would be required to manage the volumes of water typically produced in rainfall events, especially in the Sacramento Valley.

Avoid Compaction / Wheel Rutting

Wheel ruts formed by equipment passing through wet fields can create channels for water to runoff from orchards. Where possible, minimize creation of wheel ruts with dormant orchard sprayers, brush shredders or other equipment when orchard floor is saturated.

Drainage System Management

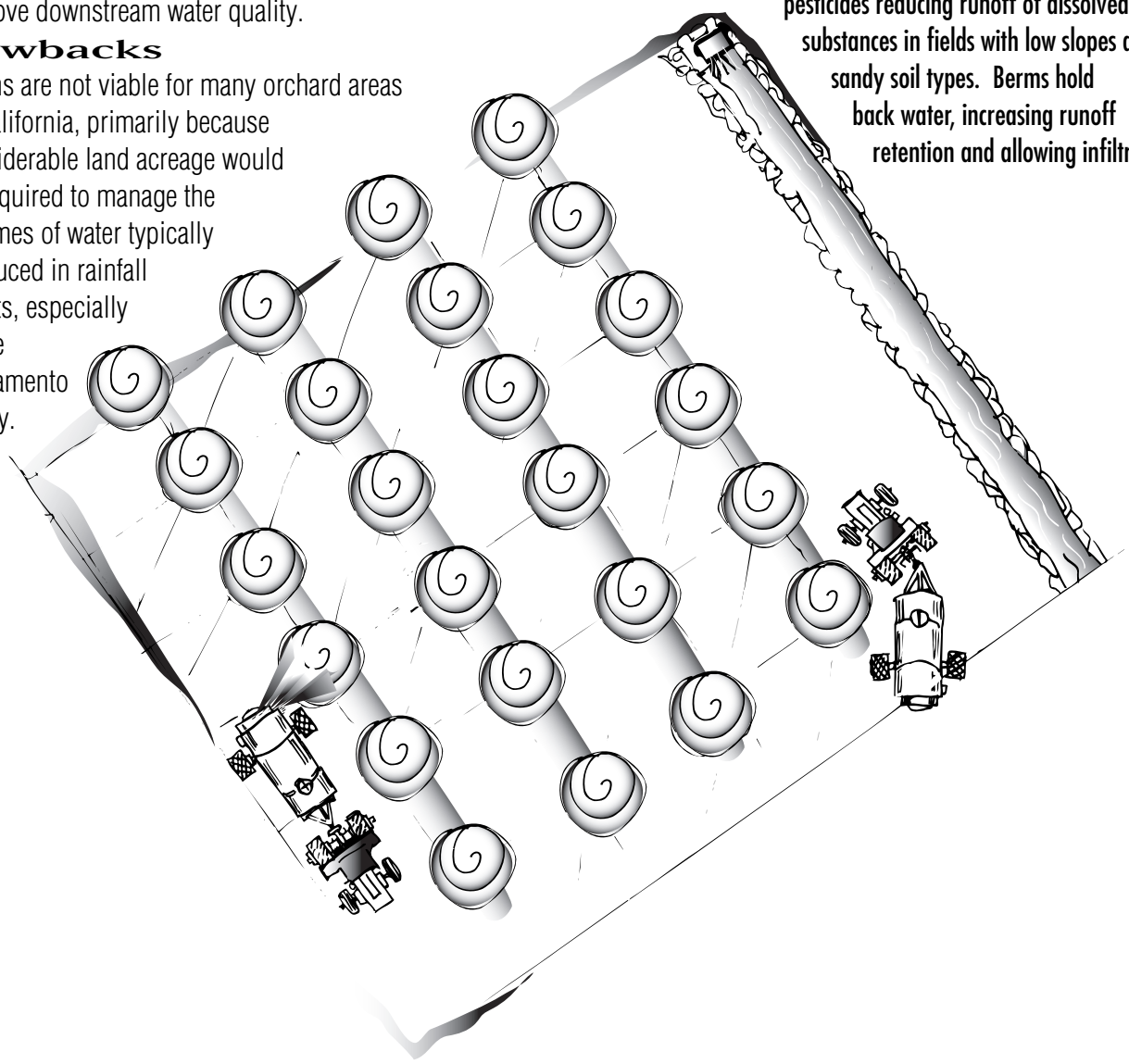
Filtering runoff water through vegetation allowed to grow in drainage ditches may help mitigate offsite movement of pesticides dissolved in storm runoff.

Avoiding Channelization of Streams and Creeks

Allowing streams to naturally flow and meander can increase runoff retention and infiltration. A modified or channeled stream could also be restored to a more natural state by re-establishment of the riparian vegetation, which also provides stream bank protection.

Berms at Low Ends of Fields (sandy soils, low slope)

Raised berms at low ends of fields can trap sediment and adsorbed pesticides reducing runoff of dissolved substances in fields with low slopes and sandy soil types. Berms hold back water, increasing runoff retention and allowing infiltration.



Soil Improvement and Increasing Water Infiltration and Retention

Practices with potential for reducing pesticide runoff from orchards in California (but not yet proven by research).

Aeration

Use of specialized tillage equipment to break crusts and aerate orchard soils with the intent of increasing water penetration and retention, thus reducing runoff. Aeration improves the soil profile with minimal disruption to the orchard floor. A finishing process may be required, however, for almond orchards where shake-and-sweep harvest methods are used. Aeration may reduce OP pesticide runoff although no studies have been conducted.

Ripped Resident Vegetation

In orchards with permanent or semi-permanent sod, vegetation is ripped at various lengths and/or depths. Ripping significantly increases soil water due to increased infiltration and porosity. Heavy rains after Fall ripping can leave orchards impassable to heavy equipment such as orchard sprayers. For stone fruits, shank depth must be shallow to avoid damage to tree roots. In recent research, ripped resident vegetation performed the best for infiltration and reduced diazinon transport, followed by non-ripped resident vegetation and bare ground being the least effective.

Improving soil texture (tilth)

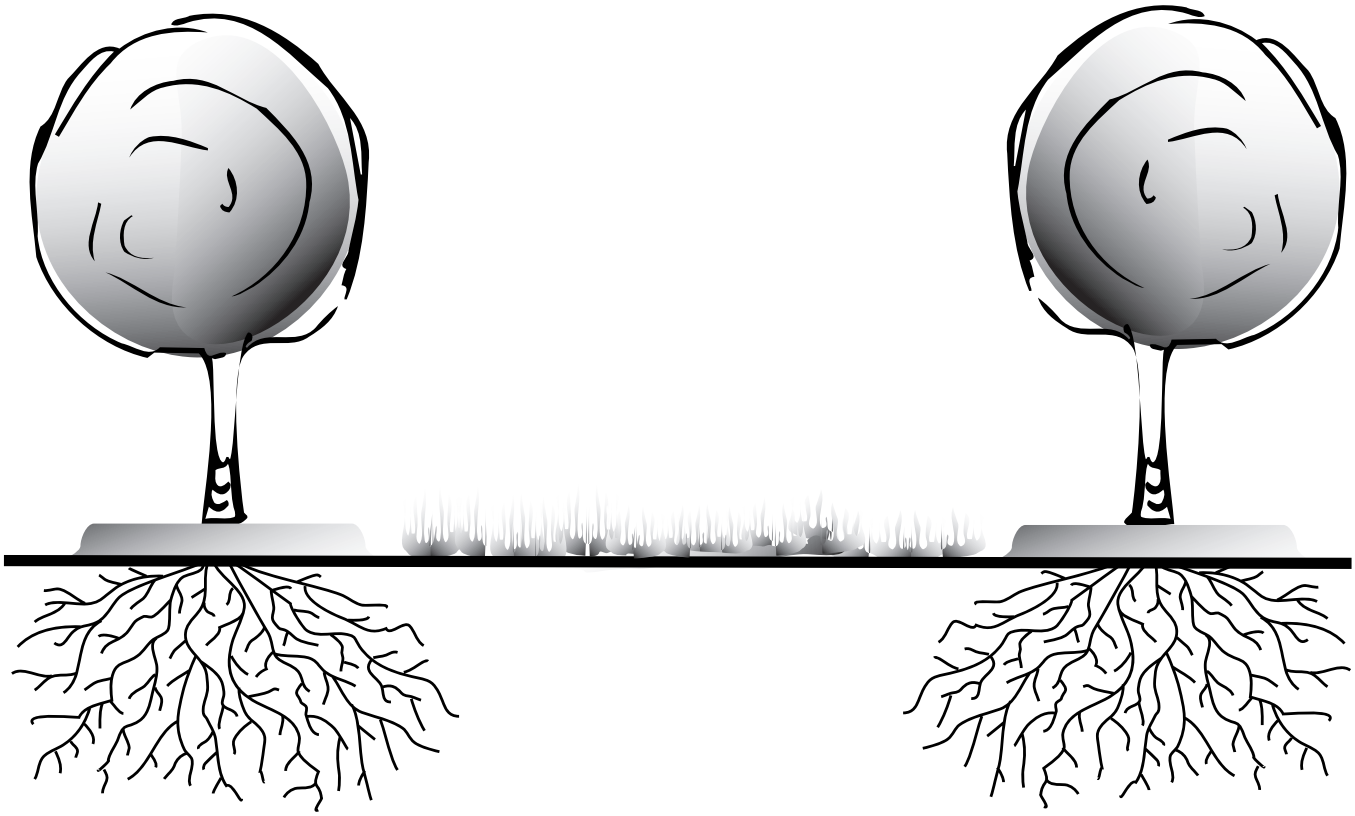
Practices such as tillage, gypsum applications or actions of earthworms have potential to increase water penetration in compacted soils or where an impermeable soil layer exists. However, no studies have been conducted to show efficacy in reducing OP pesticide runoff with these approaches.

Benefits

- Increased water penetration resulting in less runoff and increased recharging of the soil profile.
- Less water runoff means less potential for pesticides to be transported off-site.

Drawbacks

- Tillage can increase erosion under some conditions and necessitate additional orchard floor finishing work (scraping).
- Results vary with soil type and, under some conditions, compaction could increase.
- Improved soil permeability may increase movement of nitrate and other chemicals into groundwater. The balance of benefits versus disadvantages is not clear at this time and more research is needed.



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