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WEED MANAGEMENT

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Pistachios, like other crops, are grown under a wide variety of soil types, management methods and irrigation systems. In order to maintain profitable production, growers should make weed management an integral part of the total program. This should begin prior to planting new trees and extend through the life of the crop. Weed control is especially important during the first five years of growth, since heavy weed competition can significantly reduce tree vigor and productivity during this period of growth.

In addition to competition for water and nutrients, weeds may host diseases (like Verticillium wilt), insects, nematodes and rodents. Where low-volume drip or micro sprinkler irrigation is used, weeds such as yellow nutsedge, spotted spurge, sprangletop, and bermudagrass are prevelant and can interfere with the distribution of irrigation water, reducing irrigation efficiency and water available to the trees.

Since few herbicides are registered for use in pistachio orchards, growers, PCAs and fieldmen need to be familiar with all the tools available to them to achieve effective weed management. These include weed identification, records of weed infestations, field selection, sanitation and mechanical and chemical control.

UNDERSTANDING THE WEEDS PRESENT

Weed identification

Proper weed identification is essential for weed management decisions to be made effective. By being familiar with the weeds present, you can better understand how weeds grow and when and how they reproduce. All weeds grow differently and have differing growth characteristics: prostrate or erect, annual, biennial, or perennial, competitiveness for water, nutrients and light, broadleaf or grasse, method of reproduction, and timing of seed production or other reproductive structures. Properly identifying weeds directly influences herbicide selection and timing of application. Knowing that a mature weed, depending on species, may produce 10,000 to 500,000 seeds or more, makes early identification important. There are numerous weed species commonly found infesting pistachio orchards. Some of the more important ones are listed in Table 1.

Table 1. Weeds commonly found in pistachio orchards.

Summer Annuals	Winter Annuals	Perennials
Barnyardgrass	Annual bluegrass	Yellow nutsedge
Sprangletop	Filaree spp.	Bermudagrass
Large crabgrass	Cheeseweed	Johnsongrass
Lambsquarter	Mustard spp.	Field bindweed
Pigweed spp.	Chickweed	Dallisgrass
Evening primrose spp.	Shepherd's purse	Annual morningglory
Spotted spurge	Cudweed	
Sowthistle	Nettle	
Prickly lettuce		
Horseweed		
Mullein		
Flaxleaved fleabane		

Nightshade spp.		

Several publications are available that enable growers and PCAs to accurately identify weeds. Some include: *The Growers Weed Identification Handbook*, *Weeds of The West*, *Weeds of California*, and various IPM manuals available through University of California Cooperative Extension offices. Local farm advisors, specialists and consultants are excellent sources to help identify weeds. Weed samples brought to another person to identify should be stored under cool conditions and transported in a sealed plastic bag to maintain the integrity of the sample. Computer generated programs are also available on CD rom that utilize easy-to-follow instructions for the taxonomic identification of weeds. Using a personal computer and a weed program, most of the weeds found in California can be keyed out in as few as 10 steps, making it rather easy for the person to identify weeds on their own. Consult your local farm advisor or weed control specialist for further information regarding these programs.

Maintaining accurate weed records

Maintaining accurate, up-to-date records of weed infestations is important to track the progress of weeds in the field and to assist in selecting the most appropriate method(s) of control. The exact method for collecting weed data may vary amoung growers. In order to have reliable information, monitor the field at least four times during the year (winter, spring, summer, and fall). An example of a monitoring record is shown in Table 2, but others can be used.

Table 2. Weed record for field monitoring

Field		
Date		
Crop		
Herbicides/Rate		
Other Control		
Weed Species:	% Control	Notes
1.		
2.		
3.		

It is desireable to become familiar with all the weeds in the field and to monitor each of their progress. If certain weeds are are avoided or not monitored, they can soon dominate a field. In many cases these weeds are resistant to your current herbicide regime and require new methods of control. To avoid this shift in weed species, it is necessary to monitor the field frequently and rotate with effective herbicides, tillage, flailing, or other means. Maintaining records on a computer or in a field notebook will make them readily accessible as new information is gathered and for historical reasons. Weed records should include such items as herbicides and rates used, when herbicides were applied, stage of weed growth at time of treatment, degree of control, location in the field, if it is a new weed to the area, etc. Accurate records help to point out areas in the field where tough-to-control weeds (field bindweed, mullein, nutsedge, etc.) may become a problem. In the end, a little time spent monitoring for weeds can greatly impact weed control options and long-term costs.

Field sanitation

Many of the most troublesome annual weeds (including marestail, flaxleaved fleabane, and groundsel) are disseminated by wind, oriiginating from outside the immediate field. Typically they are growing along field borders or nearby ditches and cannals. Controlling these weeds with herbicides, discing, mowing and burning can help eliminate weed seed production. Many times growers achieve excellent weed control within the field, but fail to clean surrounding areas. Reducing this potential seed source can go a long way in preventing new seed entering a clean field.

PLANNING A WEED CONTROL PROGRAM

It would be ideal if one method of management could be used in all pistachio orchards, but this is obviously not possible. There are numerous local conditions that influence management decisions, including topography, soil structure and texture, permeability, type of irrigation, availability of equipment and labor, herbicide and cost, and accessibility to the orchard during wet conditions. Therefore, the specific method(s) of weed control will vary from site to site, and often include the combination of mechanical, cultural and chemical control.

Tillage vs. Non-tillage

Mechanical discing of orchards three to five times per year can be used to destroy weeds growing between the tree rows. The size of the weeds is usually not a concern, as long as the disk blades cut deep enough to destroy the weeds roots. A second pass is required, however, across the field to remove the remaining weeds growing within the tree rows. This is typically done in new plantings where cross disking is possible or prior to laying of drip lines. While effective, a major limitation is that trees can be damaged, allowing for invasion by crown rotting organisms. To avoid tree injury, a one- to two-foot strip of soil next to the trees should be left undisturbed. Controlling the remaining weeds next to the trees can be done with spot applications of postemergence herbicides (glyphosate, paraquat, sulfosate, etc.) or hand weeding during the season. Other disadvantages to discing include increased soil erosion on sloping land, soil compaction, dust (PM10), reduced water infiltration, and a general decline in productivity.

More commonly, growers disk only the middles, leaving a four- to six-foot strip of soil undisturbed within the tree row. This facilitates basin, flood, and low-volume irrigation. Mechanical mulchers, equipped with tripping mechanisms (such as the Kimco®), can then be used to destroy weeds within the tree row. Mulching at a shallow depth (one to two inches) will kill most annual weeds, as long as they are in their seedling stage of growth. Weeds larger than a few inches may already have well defined root systems and not effectivelly killed. Perennialsare not likely to be controlled and often require timely postemergence herbicide applications. To be effective on young annual weeds, several trips through the field during the season are required. Where low-volume irrigation is used, tubing should be suspended high enough to permit access by the equipment. As with discing, mechanical damage to trees is a concern and should be avoided.

Complete non-till, without the use of herbicides, is an option where resident weeds are maintained in the middles as a cover crop. This is an excellent way of reducing soil errosion on sloping ground. A flail mower can be used five to seven times per year to help maintain the weeds in a low-growing state. This method of management also allows for better field access and reduced soil compaction. Mowing too close to the soil surface will create dust and should be avoided. A well-established cover crop that is seeded , in itself, can out-compete weeds growing in the middles. The specific cover crop used is left up to the individual grower, depending on what the grower is trying to achieve (weed control, trap crop, soil amendment, etc.), and weeds growing down the tree row still need to be managed.

Where do herbicides fit in?

While tillage practices can be a beneficial means of managing weeds, it is often expensive. Herbicides, when properly used, can be a cost-effective tool for controlling weeds in most pistachio orchards. While, there are fewer herbicides registered for use in pistachio orchards in California than in

other perenial crops (like grapes), they can be effective at reducing weed populations. These herbicides are either selective or nonselective in their activities. Table 3 shows the current herbicides registered for pistachio orchards in California and their times of application.

In order to select the most effective herbicide or combination of herbicides, one must first identify the weeds and know their susceptibility to the various herbicides. Weed charts are included at the end of this chapter along with charts summarizing their individual performance under various conditions in the central San Joaquin valley (Charts 1, 2 and 3). These charts should only serve as *guidelines* for herbicide selection. They are not intended to be recommendations for selection or use. Consult a PCA or crop consultant for written recommendations.

Local conditions such as soil type, method and frequency of irrigation, and availability of application equipment can affect herbicide selection and performance. Herbicides are either applied to the soil (preemergence) and activated by water to kill weed seeds or applied directly to actively growing weeds (postemergence) for "burn-down" control. Furthermore, they are either selective or nonselective in their activities. Preemergence herbicides are applied to bare soil to kill germinating weed seeds, before they apear from the soil. These herbicides are degraded primarily by photodecomposition, hydrolysis, and microbiological activity. Therefore, local conditions (soil type, method of irrigation, etc.) may influence the degree of herbicide persistence. Regardless of the particular preemergence herbicide(s) used, they should be sprayed on a soil surface that is relatively free of leaves and other debris.

Postemergence herbicides are applied directly to activity growing weeds. They have either contact or systemic activity and require uniform wetting of the weeds to be effective. Postemergence herbicide performance, may vary, depending on the weed species present, weed vigor, and uniformity of application. Weeds that are droughty, stressed, or have hairy, mealy or waxy leaves may not be effectively controlled with postemergent herbicides once they get to large.

Table 3. Herbicides registered for use in pistachio orchards in California
And their times of application.

Non-Bearing Pistachio Orchards

Prior to Planting - Postemergence
glyphosate (Roundup Ultra®) w or w/o surfactant
oxyfluorfen (Goal®)
paraquat (Gramoxone Extra®) + NIS
sulfosate (Touchdown®) or w/o surfactant

Soil Applied - Preemergence
isoxaben(Gallery T&V®)
napropamide (Devrinol®)
oryzalin (Surflan®)
oxyfluorfen (Goal®)
pendimethalin (Prowl®)
thiazopyr (Visor®)

Postemergence - Selective
clethodim (Prism®) + COC
fluazifop-p (Fusilade DX®) + COC
sethoxydim (Poast®) + COC

2,4-D amine (various trade names)

Postemergence - Non-Selective
oxyfluorfen (Goal®)
paraquat (Gramoxone Extra®) + NIS
glyphosate (Roundup Ultra®) w or w/o surfactant
sulfosate (Touchdown®) w or w/o surfactant

Bearing Pistachio Orchards

Soil Applied Preemergence
napropamide (Devrinol®)
oxyfluorfen (Goal®)
oryzalin (Surflan®)

Postemergence - Selective
2,4-D (various trade names)

Postemergence - Non-Selective
glyphosate (Roundup Ultra®) w or w/o surfactant
oxyfluorfen (Goal®)
paraquat (Gramoxone Extra®) + NIS
sulfosate (Touchdown®) w or w/o surfactant

NIS = nonionic surfactant
COC = crop oil concentrate

Herbicide performance under various methods of irrigation

Pistachio orchards in California are irrigated by a number of methods, including low-volume drip, low-volume microsprinklers, microjets or misters furrow; basin-flood, solid-set sprinkler; and drag-line sprinkler.

Low-volume irrigation is common in California pistachio orchards. Unlike furrow, basin-flood or overhead sprinkler irrigation, low-volume systems improve uniformity in irrigation application and efficiency, and make sure the needs of the trees are being met. However, low-volume irrigation water applied too frequently can significantly influence the leaching of herbicides, their selectivities, and persistence or degradation in the soil. The behavior of herbicides under various soil textures and irrigation techniques must be considered in their selection. Preemergence herbicides are generally more stable on heavier soils than on lighter soils. Orchards using low-volume systems cause weeds to grow vigorously in the wetted area near the emitters. This requires close observation of their growth, and usually repeated treatments of postemergence herbicides. Weeds can also interfere with the uniform distribution of water, making monitoring of the system difficult.

When preemergence herbicides are applied to trash-free soils and activated by rainfall, sprinkler, and other forms of irrigation, product performance is enhanced. However, if water is applied to frequently, degradation can be increased. Herbicide performance can, therefore, depend a great deal on the length and frequency of irrigation. While oxyfluorfen appears to persist for several months, other herbicides, like napropamide, may only last one-third as long under the same wetted conditions. Postemergence herbicide activity is also influenced by weed growth in the wetted area near emitters. Those weeds growing near the emitter often grow vigorously. This makes timing the application of postemergence herbicides important. The smaller the weeds are, the easier they are to control. Herbicides like glyphosate, sethoxydim, sulfosate, etc. require accurate timing of application to be effective. For example, spotted spurge can grow rapidly and set seed in 30 days or less, so treatment must occure shortly after emergence. Weeds like horseweed, cudweed and flaxleaved fleabane, growing along the

perimeter of the wetted area, may be droughty and difficult to control and also require close attention. Managing weeds growing under low-volume irrigation requires special attention and timely herbicide treatment for effective control.

Selecting an herbicide program

Herbicides play an important role in weed management in pistachio orchards. While no one herbicide controls all the weeds, each can contribute to obtaining a weed-free field. One of the most popular herbicide programs in pistachio orchards involves the application of a tank mix of oryzalin plus oxyfluorfen in the fall, following harvest with a repeat treatment in the winter prior to bud break. Leaves and other debris should be blown from the tree rows prior to treatment to allow for good contact of the soil surface. If weeds are present at the time of application, a postemergence herbicide should be added to the spray tank. "Burning down" emerged weeds with postemergence herbicides, or mulching them in mechanically before preemergence herbicides are used, will allow for better distribution of the soil treatment, especially if oryzalin is to be used. It is known that oryzalin adheres to organic matter, so removing weeds and other debris ahead of the preemergence treatment would help improve control. Horseweed or flaxleaved fleabane are not adequately controlled with, oryzalin, oxyfluorfen or napropamide, and require an herbicide like glyphosate or paraquat to be effective. If cudweed is predominant, napropamide would be an effective option. In non-bearing orchards, thiazopyr would be an effective preemergence herbicide if yellow nutsedge is anticipated. However, the treatment should be applied in the fall following harvest ahead of rains. Late winter or spring treatments of thiazopyr are not effective on nutsedge. Regardless of the soil persistent herbicide(s) used, timely incorporation is needed. The time period required for incorporation by rainfall or irrigation following application is shown in Table 4.

Table 4. Time required for incorporation of soil persistent herbicides

Herbicide	Maximum time to incorporate
napropamide	< 21 days (Nov. – Feb.)
napropamide	< 24 hours (Mar. – Oct.)
oryzalin	< 21 days
pendimethalin	< 21 days (rainfall) < 7 days (mechanically)
oxyfluorfen	< 28 days
thiazopyr	<21 days
isoxaben	< 21 days

Although napropamide controls some winter grasses and composite species better than oryzalin, it is less effective against many summer annual weeds and under low-volume frequent irrigation has less persistence in the soil than oryzalin, especially during wet years. Oxyfluorfen complements both napropamide and oryzalin and controls a wide spectrum of summer and winter annuals, including cheeseweed, filaree and clovers (preemergence control only). Oxyfluorfen may also be used at low rates to control established annual broadleaf weeds when they are in their seedling stage of growth and growing vigorously. Oxyfluorfen can be applied to bearing pistachio orchards from May 1 to seven days prior to harvest (1995, Special Local Needs). This gives greater flexibility for controlling late germinating winter annuals in the spring (such as filaree, cheeseweed, etc.) as well as summer annuals, including lambsquarter, prickly lettuce and nightshade.

Although pendimethalin controls many of the same weeds as oryzalin, it is only registered in nonbearing orchards. Studies are being conducted under the guidance of Inter Regional Project Number 4 (IR-4) to label pendimethalin for use in bearing orchards in the future. Where low-volume microsprinklers are used, oryzalin and napropamide can be metered through the system to control summer weeds growing near the emmiters. Herbicides injected through the irrigation system should meet strick guidelines and are applied for the duration of the irrigation, leaving enough time to flush the system at the end of the application. Treatment by this method not only reduces overall herbicide amounts applied, but also ensures placement of the herbicide in the wetted area where summer weeds tend to proliferate.

Selective postemergence grass herbicides (clethodim, fluazifop-p, and sethoxydim) applied with a crop oil concentrate will control established annual and perennial grasses in non-bearing orchards. To be effective, the grasses must be growing vigorously and in their seedling stage of growth (prior to tilling). Repeated applications will often be required to control perennial grasses like Johnsongrass or bermudagrass. For effective control of susceptible grasses, uniform wetting of the foliage is needed. However, annual bluegrass, bromes, fescues, and witchgrass will only be be controlled with clethodim, if treated at their earlier stages of growth.

Herbicides applied through low-volume spray equipment

Typical ground sprayers often require carrying large amounts of water (20 to 50 gal/acre) for application of herbicides. To reduce the amount of water and trips through the field needed, controlled droplet applicators (CDA) are frequently used. These systems use nozzles that produce very fine dropplets, increasing the spray concentration and reducing the water to be carried. Most low-volume systems can operate at between 3 and 5 gallons per acre. CDAs are generally mounted to the tool bar of a tractor or on an ATV. ATVs allow for better field access under wet conditions than heavier tractors. Herbicides applied in this manner are used at higher concentrations, but still require accurate placement of the spray solution. "Chemical mowing" of the vegetation can be maintained when glyphosate is used at low rates and at monthly intervals. Using glyphosate at low rates like this can lead to shifts in weed populations if used over a long period of time. However, the use of CDA units on light equipment does reduces soil compaction. Since CDA units distribute smaller water particles than a standard spray rig, nontarget drift is more likely to occur. Non-selective herbicides, such as glyphosate, 2,4-D amine or sulfosate can cause significant crop injury when young tissue or leaves are contacted. Symptoms may range from minor chlorosis to severe leaf "strapping" (in the case of glyphosate and sulfosate), and leaf and petiole malformations (with 2,4-D amine), resulting in loss of vigor, reduced production, and a general decline of the trees. To avoid injury to the trees, apply the herbicide with a hooded or shielded sprayer under calm conditions.

Other sprayer technology

Advances in sprayer technology have led to the production of a sprayer unit capable of spraying green vegetation without spraying bare ground. This "Weed Seeker®" sprayer utilizes a light source to activate solenoids and accompanying nozzles when the sprayer "sees green. If used under minimal weedy conditions, it can save 30% or more in the amount of herbicide applied to the field. Because the unit is self-calibrating, it allows the operator to go from the shop to the field in a matter of minutes without manually calibrating the spray equipment.

CONCLUSION

Pistachio growers in California have many tools (both chemical and nonchemical) available which enable them to develop a weed management program to meets their individual needs. Effective weed control can be achieved in pistachio orchards with or without the use of herbicides. It cannot be overemphasized that, when herbicides are used, proper weed identification and accurate application is imperative for cost-effective. By being familiar with all the available tools and knowledge of the weed

infestation, all growers can produce pistachios relatively free of competing weeds in a manner that is economically and environmentally sound.

Please continue to the following pages for charts 1, 2 and 3.