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. A plan to control weeds should be in place before planting trees and carried through the life of the orchard. Weed control is especially critical during the first years of establishment, since heavy weed competition can reduce early tree vigor and productivity.

In addition to direct competition for water and nutrients, certain weeds host several important insects (like lygus, Green Plant Bug, and False Chinch Bug), diseases (like Verticillium wilt), nematodes, and rodents. Where low-volume drip or micro-sprinkler irrigation is used, weeds such as yellow nutsedge, spotted spurge, sprangletop, and bermudagrass become prevalent, interfering with water distribution and reducing irrigation efficiency.

Since few herbicides are registered in pistachio orchards (particularly in bearing fields), growers, PCAs, and field managers need to be familiar with all the tools available to select the most appropriate management strategy and achieve effective control. These tools include field selection, weed identification, monitoring weeds, sanitation, and mechanical and/or chemical control.

GETTING OFF TO A CLEAN START

Field selection

While many considerations go into deciding on specific fields to plant pistachios, it is important to realize that long-term weed control strategies are directly influenced by site selection. In order to reduce the costs associated with weed control, select fields that are known to be relatively free of troublesome annual and perennial weeds. Fields with a history of perennial weeds, like nutsedge, field bindweed, dallisgrass, johnsongrass, and bermudagrass should be avoided, since they are difficult to eradicate once established. If one has to plant into fields already infested with these or other troublesome weeds, one may be better served by dedicating efforts at controlling these weeds before new trees are planted. Although this ties up land for a time, it can help reduce weed control costs for many years after planting. Unfortunately, there are no inexpensive or easy solutions available to control perennial weeds once established in new tree plantings. So, starting off with relatively clean fields can be a large advantage for long-term effective weed management.

UNDERSTANDING THE WEEDS PRESENT

Weed identification

Proper weed identification is essential for weed management decisions to be effective. By being familiar with the weeds present, you can better understand how they grow and reproduce. Weeds have differing characteristics, making them unique from each other. They have different life cycles (annual, biennial, or perennial), have differing general plant structures (broadleaf, grass, or sedge), grow flat or erect, reproduce by seed and/or other reproductive structures (rhizomes, tubers, stolons, etc.), and compete differently for valuable resources. Properly identifying weeds is especially important when deciding on herbicide selection, rates to use, and application timing. 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	Bermudagrass
Hairy fleabane	Cheeseweed	Dallisgrass
Lambsquarters	Chickweed	Field bindweed
Large crabgrass	Cudweed	Johnsongrass
Marestail	Filaree spp.	Nutsedge, purple
Pigweed spp.	Mustard spp.	Nutsedge, yellow
Prickly lettuce	Nettle	
Sowthistle	Shepherd's purse	
Spotted spurge		
Sprangletop		
Turkey mullein		

Several publications are available that can help growers, PCAs, and managers to accurately identify weeds. Some include: *The Growers Weed Identification Handbook*, *Weeds of The West*, and *Weeds of California*. Various IPM manuals are also available at University of California Cooperative Extension county offices that include weed photos and descriptions. Local farm advisors, specialists, and consultants are excellent sources to help identify weeds. If unsure of the weeds in your field, collect samples and bring them to someone to be identified. Weed samples should be stored under cool conditions and transported in a sealed plastic bag to maintain sample integrity. Computer programs are also available on CD-ROM that have easy-to-follow instructions for the taxonomic identification of weeds. Using a personal computer and a weed program, many of the weeds found in California can be identified in less than seven or eight steps. Consult your local farm advisor for further information regarding the programs available.

Maintaining accurate weed records

Maintaining accurate, up-to-date weed records is important to track the distribution of weeds in the field. It also helps in choosing the most appropriate method(s) of control. The exact method of collecting weed data is not set in stone, and often varies from grower to grower. One such method of monitoring is as follows and requires five simple steps: 1) Walk several locations of the field two or three times per year (winter, spring, and summer) and identify the weeds present, 2) Rate each of the weeds found on a 1-10 scale (1= very few present or not a problem, 3= moderate infestation, and 5= very heavy infestation or dominates most other weeds), 3) Make note of weeds escaping herbicide or mechanical treatment, new weeds, or a shift in the type of weeds, 4) Map or list particular areas that show new weeds, escapes, or shifts in populations, and 5) Maintain these records in a file or computer, where they can be readily accessed and updated. An example of a weed monitoring record is shown in Table 2.

Table 2. Weed record for field monitoring

Date	**Field**	**Crop**
Herbicide(s) used	**Rate(s) used**	**Date(s) treated**
Weeds present	**Weed rating**	**Notes**
1.		
2.		
3.		
4.		
5.		

It is desirable to become familiar with all the weeds in the field and to monitor each of them. If certain weeds are not controlled or not monitored, they can soon dominate a field. In some cases, these weeds may be resistant to your current herbicide regime and require new methods of control. To avoid this shift in weeds, it is necessary to monitor the field frequently and rotate with effective herbicides, mechanical, or other means. Accurate records help to point out areas in the field where tough-to-control weeds (field bindweed, mullein, nutsedge, etc.) may pose a problem. By routinely monitoring for weeds, you can alter your herbicide program, based on changing weed patterns. A little time spent monitoring for weeds can help you select appropriate herbicides, rates, and other control options to reduce long-term costs.

Field sanitation

Many of the troublesome annual weeds (like hairy fleabane, groundsel, and marestail) are disseminated by wind, often originating from outside the field. Typically they are growing along field borders or nearby ditches and canals. Controlling these weeds with herbicides, disking, mowing, and burning can help eliminate seed production. Many times growers achieve excellent weed control within the field, but fail to clean surrounding areas. Reducing this seed source by eliminating weeds before they set seed is a must to prevent new invasions into the field.

DEVELOPING A RELIABLE WEED CONTROL PROGRAM

It would be ideal if one method of weed management could be used in all pistachio orchards, but this is obviously not possible. There are many 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. The specific method(s) of weed control will vary from site to site, but usually include the combination of mechanical, cultural, and chemical control options.

Tillage vs. Non-tillage

Tillage options are normally limited to the area between tree rows. In-row tillage can be practiced in new plantings when low-volume irrigation tubing has not been laid out or has been suspended off the soil surface. In established plantings, disking can be used to eliminate weeds growing between 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, although smaller weeds are easier to kill. In new plantings where irrigation tubing has not been laid out, a second pass can be made across the field to remove the remaining weeds growing within the tree rows. A major limitation to cross-disking 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 weeds emerged next to the trees can be done with spot applications of post-emergence herbicides like glyphosate, paraquat, or sulfosate, or hand weeding during the season. Other disadvantages to disking include increased soil erosion on sloping land, soil compaction, dust, 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 as long as trees are staked. Mulching at a shallow depth (1 - 2 inches) will kill most seedling annual weeds. Weeds larger than three or four inches tall may already have well defined root systems and are not easily killed. Perennials will not be controlled and often require timely post-emergence 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 disking, mechanical damage to trees is a concern and should be avoided.

Complete non-tillage is an option where weeds are maintained in the middles as a green cover. This is an excellent way of reducing soil erosion, especially on sloping soils. A flail mower can be used five to seven times per year to help maintain the weeds in a low-growing state. This 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 cover crop can also be planted to compete with the weeds 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 the cost. Weeds growing down the tree row still need to be managed.

Where do herbicides fit?

While tillage practices can be beneficial for 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 in pistachios in California than in many other perennial crops (like grapes or almonds), they are important for managing weeds. Since there are fewer herbicides registered in bearing than non-bearing orchards, it is important that you reduce the weed population as much as possible before pistachios begin bearing nuts. Table 3 shows herbicides registered in pistachio orchards in California and their times of application.

Table 3. Herbicides registered in pistachios in California and their timing of application

Non-Bearing Pistachio Orchards	***Bearing Pistachio Orchards***
Before Planting	**After Planting**
Pre-emergence	Pre-emergence
metham sodium (Vapam HL®, Sectagon 42®, etc.)	napropamide (Devrinol®)
	oxyfluorfen (Goal®)
Post-emergence (selective)	oryzalin (Surflan®)
fluazifop-p-butyl (Fusilade DX®) + COC or NIS	
sethoxydim (Poast®) + COC	Post-emergence (selective)
	sethoxydim (Poast®) + COC
Post-emergence (non-selective)	
glyphosate(Roundup Ultra®, Glyphomax®, etc.)	Post-emergence (non-selective)
paraquat (Gramoxone Extra®) + COC or NIS	glyphosate (Roundup Ultra®)
sulfosate (Touchdown®)	paraquat (Gramoxone Extra®) + COC or
NIS	
	2,4-D amine (Amine 4®, etc.) – at least 1
year old	
After Planting	
Pre-emergence	
isoxaben (Gallery T&V®)	Note: COC = crop oil concentrate and
napropamide (Devrinol®)	NIS = non-ionic surfactant
oryzalin (Surflan®)	
oxyfluorfen (Goal®)	
pendimethalin (Prowl®)	
thiazopyr (Visor®)	
Post-emergence (selective)	
clethodim (Prism®) + COC or NIS	
fluazifop-p-butyl (Fusilade DX®) + COC or NIS	
sethoxydim (Poast®) + COC	
Post-emergence (non-selective)	
diquat dibromide (Reglone®) + NIS	
glyphosate (Roundup Ultra®, Glyphomax®, etc.)	
paraquat (Gramoxone Extra®) + COC or NIS	
sulfosate (Touchdown®)	
2,4-D amine (Amine 4®, etc.) – at least 1 year old	

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 showing various weeds that are susceptible to the herbicides registered in pistachios are included at the end of this chapter (Charts 1 and 2). These charts should only serve as *guidelines* for your choice of herbicide. They are not intended to be recommendations for selection or use. Consult your PCA for written recommendations.

Herbicides are either applied to the soil (pre-emergence) to kill germinating weed seeds before they emerge from the soil or applied to actively growing weeds (post-emergence). Pre-emergence herbicides need to be activated by rainfall or irrigation water and post-emergence herbicides require proper spray coverage for "burn-down" control. Pre-emergence herbicides in particular are degraded by photodecomposition, hydrolysis, or microbiological activity. Therefore, local conditions such as soil type, method or frequency of irrigation, and environmental conditions will influence herbicide persistence and performance. Regardless which pre-emergence herbicides are used, they should be sprayed on berms that are free of leaves and debris.

Post-emergence herbicides applied directly to activity growing weeds are either selective or non-selective, and have contact or systemic activity. Contact-type herbicides (like paraquat) require uniform, and complete spray coverage of the weeds to be effective. The performance of post-emergence herbicides will vary depending on the weed species present, weed size, vigor or growth, and uniformity of application. Weeds that are droughty, stressed, or have hairy, mealy or waxy leaves are more difficult to control. Weeds should be small (less than 4" tall) when using post-emergence herbicides.

Herbicide performance under various methods of irrigation

Pistachio orchards in California are irrigated by a number of methods, including low-volume drip, low-volume micro-sprinklers, micro-jets or misters, furrow; basin-flood, solid-set sprinkler, and drag-line sprinkler. Low-volume, frequent irrigation is common in pistachio orchards. Unlike furrow, basin-flood or overhead sprinkler irrigation, low-volume systems improve irrigation uniformity and efficiency, while meeting the requirements of the trees. However, orchards having low-volume irrigation systems also encourage weeds to grow vigorously in the wetted area near the emitters. This requires close monitoring of weed growth so weeds don't become too large for control. Repeat applications with post-emergence herbicides are usually needed to eliminate weeds for maximum emitter performance. Weeds growing close to emitters also make monitoring of the system difficult. When low-volume irrigation water is applied too frequently, it can significantly influence performance and degradation of pre-emergence herbicides. The behavior of herbicides under differing soil textures and irrigation techniques must be considered when selecting pre-emergence treatments. Pre-emergence herbicides are generally more stable on heavier soils than on lighter soils and usually persist longer under periodic wetting of the soil.

When pre-emergence herbicides are applied to clean berms and activated by rainfall, sprinkler, or other forms of irrigation shortly after treatment, performance is enhanced and degradation by UV light is reduced. However, if water is applied too frequently, degradation can be increased through breakdown or leaching processes. Herbicide performance can, therefore, depend a great deal on the length and frequency of irrigation. While oxyfluorfen appears to persist for several months under frequently wetted conditions, other herbicides, like napropamide, may only last one-third as long under the same conditions.

Post-emergence herbicide is influenced by degree of weed growth in the wetted area near emitters. Weeds growing near emitters grow vigorously, making timing of application important. It also usually requires multiple applications for season-long control. The smaller the weeds are, the easier they are to control. Herbicides like glyphosate, sethoxydim, sulfosate, etc., require accurate

timing to be effective. For example, spotted spurge can grow rapidly and set seed in less than 30 days, so treatment must occur shortly after emergence. Weeds like cudweed, hairy fleabane, marestail, and mullein growing along the perimeter of the wetted area, may be droughty and difficult to control, so should be treated shortly following emergence, before they become stressed. Managing weeds growing under low-volume irrigation requires special attention and timely herbicide treatment for effective control.

Selecting an effective 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 relatively weed-free field. Regardless of the herbicide or combination of herbicides used, it is important that you properly identify the weeds present to insure the best degree of control.

Regardless of the pre-emergence herbicide(s) used, leaves and other debris should be blown from the tree rows prior to treatment to allow for good herbicide-soil contact. If weeds are present at the time of application, a post-emergence herbicide should be added to the spray tank. "Burning down" emerged weeds with post-emergence herbicides, or mulching them in mechanically before pre-emergence herbicides are used, will allow for better distribution of the soil treatment, especially where napropamide or oryzalin are used. It is known that these two herbicides adhere to organic matter, so removing weeds and other debris ahead of their application improves residual control.

An important factor in selecting pre-emergence herbicides is the amount of time they can remain on the soil surface before they begin to degrade and should be incorporated for activation. The time period required for incorporation of pre-emergence herbicides by rainfall, irrigation, or mechanical means following application is shown in Table 4. In order for napropamide to be effective, it needs to be incorporated with rainfall within four days after application. Hence, where large acreages are to be treated, it may be to difficult to time the treatment close enough to rainfall for the treatment to be effective.. Both oryzalin and oxyfluorfen can remain stable on the soil surface for three to four weeks before rainfall or irrigation occurs.

Table 4. Time required for incorporation of pre-emergence herbicides

Herbicide	Maximum time to incorporate with water
isoxaben	< 21 days
napropamide	< 4 days
oryzalin	< 21 days
oxyfluorfen	< 28 days
pendimethalin	< 21 days < 7 days (mechanically)
thiazopyr	<21 days

One of the most popular herbicide programs in non-bearing or bearing pistachio orchards is the application of a tank mix of oryzalin plus oxyfluorfen in the fall after harvest, with a repeat treatment in the winter prior to bud swell. Glyphosate, paraquat, or sulfosate are usually added to the tank when weeds are emerged at the time of treatment. Hairy fleabane or marestail are not adequately controlled with, oryzalin, oxyfluorfen, or napropamide, and require post-emergence herbicides like glyphosate or paraquat to be effective. If cudweed predominates, napropamide would be an effective option.

While napropamide controls some winter grasses and sunflower species better than oryzalin, it is usually less persistent in the soil than oryzalin under low-volume frequent irrigation. Oxyfluorfen complements both napropamide and oryzalin and controls a wide spectrum of summer and winter annuals, including cheeseweed, chickweed, and clovers (pre-emergence control only). Oxyfluorfen may also be used at low rates to control established annual broadleaf weeds when they are growing vigorously in their seedling stage of growth. Oxyfluorfen can be applied to bearing pistachio orchards from May 1 to seven days prior to harvest (1995, SLN). This gives greater

flexibility for controlling late germinating winter annuals in the spring (such as filaree, cheeseweed, etc.) as well as summer annuals (like lambsquarters, prickly lettuce, and nightshade). Oxyfluorfen should not be applied near bud swell or early fruit set or injury may result.

Pendimethalin controls many of the same weeds as oryzalin, but is only registered in non-bearing orchards. In non-bearing orchards, thiazopyr can provide excellent control of yellow nutsedge applied in the fall and again in the spring. Reduced rates of thiazopyr are used when susceptible annual weeds are targeted. Regardless of the pre-emergence herbicide(s) used, timely incorporation is needed.

Where low-volume micro-sprinklers are used, oryzalin and napropamide can be metered through the irrigation system to control summer annual weeds growing near the emitters. Herbicides injected through the irrigation system should meet label guidelines and should be applied for the duration of the irrigation, leaving only enough time to flush the system at the end of the application. Treatment by this method not only reduces overall herbicide amounts applied (compared to a solid berm treatment), but also aids in placement of the herbicide in the wetted area where summer weeds can proliferate.

Selective post-emergence grass herbicides (clethodim, fluazifop-p butyl, and sethoxydim), applied with an appropriate surfactant, will control established annual grasses in non-bearing orchards, but do not control sedges or broadleaf weeds. To be effective, annual grasses must be growing vigorously, in their seedling stage of growth (prior to tilling), and the application must be sufficient to wet to the growing point (located at the soil surface). A spray volume of at least 30 gpa is recommended for effective grass control. Annual bluegrass, bromes, and fescue species will only be controlled with clethodim, if treated at early stages of growth. Repeated applications of grass herbicides will be required for control of perennial grasses, like johnsongrass, where regrowth is likely to occur from reproductive structures (such as rhizomes). In general, perennial grasses are best controlled when the application is delayed until there is six to 12” of regrowth. This allows for stored carbohydrates to be used up prior to treatment, and reduce the amount available for subsequent regrowth. Where possible, it is desirable to mechanically chop or disk underground rhizomes and roots into smaller pieces prior to treatment. While there may be an increase in the number of plants to control, they will have less storage reserves than the original plants and can be easier to eradicate.

Herbicides applied through low-volume spray equipment

Standard ground sprayers often require carrying large amounts of water (20 to 50 gal/acre) for application of herbicides (generally limited to glyphosate or sulfosate). To reduce the amount of water carried and trips through the field needed, controlled droplet applicators (CDA) are frequently used. These systems use nozzles that produce very fine droplets, increasing the spray concentration and reducing the amount of water or carrier needed. Most low-volume systems are designed to deliver less than five gallons per acre of spray solution. CDAs can be easily mounted to an ATV, which allow for better field access under wet conditions than heavier tractors and reduce soil compaction. Herbicides applied in this manner are used at higher concentrations, but still require accurate placement of the spray solution. Since CDAs distribute smaller water particles than standard sprayers, non-target drift is more likely to occur. Non-selective herbicides, such as glyphosate, paraquat, sulfosate, or 2,4-D amine 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), foliage necrosis (with diquat or paraquat), 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 herbicides with a hooded or shielded sprayer under calm conditions.

Weeds can be managed in the middles using "chemical mowing". Here, glyphosate or sulfosate is used at low rates and applied at monthly or bi-monthly intervals to maintain

low growing vegetation. Care should be taken when using this technique in order to prevent shifts in weed populations that are exposed to sub-lethal doses over a period of time.

Other sprayer technology

Advances in sprayer technology have led to the production of a sprayer capable of spraying green vegetation without spraying bare soil. The "Weed Seeker®" sprayer utilizes a light source to activate solenoids and a series of nozzles to allow the sprayer to treat where it "sees" green plant tissue. If used under minimal weedy conditions, it can save 30% or more in the amount of herbicide (usually glyphosate or sulfosate) applied to the field compared to a broadcast application. The degree of savings is based on the amount of weed cover in the field and the size of the acreage to be treated. Fields with less than 40% of the soil covered by weeds provide optimize performance. Where weeds are found in clumps or bunches, performance is excellent. Studies have shown, that an orchard size of 400 acres, with 40% weed cover can save you $800 or more per application compared to an orchard of 100 acres in size. Additionally, a weed cover rating of 5% can save $400 over a field with 40% weed cover. Because the unit is self-calibrating, it allows the operator to go from the shop to the field in a matter of minutes without having to manually calibrate the sprayer. This type of sprayer performs equally under dark or light conditions. So, applications can be made in the early morning or during the evening when conditions tend to favor calmer conditions in the central valley of California and less potential for drift.

CONCLUSION

Pistachio growers in California have several tools (both chemical and non-chemical) available that can help 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 control. 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.

Chart 1. Susceptibility of Annual Broadleaf Weeds to Herbicides Registered in Pistachio Orchards in California

	Preemergence							Postemergence								
C = Control P = Partial control N = No control -- = No information	**FLUM**	**ISOX - NB**	**NAPR**	**ORYZ**	**OXYF**	**PEND - NB**	**THIA - NB**	**CLET - NB**	**DIQU - NB**	**FLUA - NB**	**GLYP**	**HALO**	**OXYF**	**PARA**	**SETH - NB**	**2,4-D**
Annual Broadleaves																
Ann. morningglories	C	C	P	P	C	N	--	N	P	N	C	P	C	P	N	P
Cheeseweed	C	C	P	P	C	P	P	N	N	N	P	N	C	P	N	P
Chickweeds	C	C	C	C	P	C	P	N	C	N	C	C	N	C	N	N
Clovers	--	P	P	N	P	N	--	N	P	N	P	N	N	P	N	N
Cockleburs	--	--	P	N	P	N	N	N	P	N	C	C	C	C	N	C
Cudweeds	--	C	C	N	N	N	C	N	N	N	C	N	C	N	N	P
Fiddlenecks	--	C	C	C	C	C	C	N	P	N	C	N	C	P	N	P
Filarees	C	C	C	P	C	N	C	N	P	N	P	N	C	P	N	C
Goosefoot, nettleleaf	C	C	C	C	C	C	C	N	C	N	C	N	C	C	N	C
Groundcherries	C	C	N	N	C	N	P	N	C	N	C	N	C	C	N	C
Groundsel, common	C	C	P	P	C	N	C	N	C	N	C	C	C	C	N	P
Hairy fleabane	P	C	N	N	P	N	P	N	C	N	C	N	P	P	N	C
Henbit	C	C	P	C	C	C	P	N	C	N	C	N	C	C	N	P
Horseweed	C	C	N	N	P	N	P	N	P	N	C	N	P	P	N	C
Knotweed, common	--	C	C	C	P	C	C	N	P	N	P	N	N	P	N	P
Lambsquarters, common	C	C	C	C	C	C	P	N	C	N	C	N	C	C	N	C
London rocket	C	C	C	P	C	P	P	N	C	N	C	C	P	C	N	C
Mullein, turkey	--	C	P	N	P	N	C	N	P	N	P	N	N	P	N	P
Mustards	C	C	P	N	C	P	P	N	C	N	C	C	P	C	N	P
Nettles	C	C	P	P	C	N	C	N	P	N	N	C	C	P	N	P
Nightshades	C	C	N	N	C	N	P	N	C	N	C	N	C	C	N	C
Pigweeds	C	C	C	C	C	C	P	N	C	N	C	P	C	C	N	P
Prickly lettuce	P	C	C	N	C	N	C	N	P	N	C	C	P	P	N	C
Primrose, cutleaf evening	--	C	P	P	P	P	C	N	C	N	C	N	P	C	N	--
Puncturevine	C	C	P	C	P	P	P	N	C	N	C	N	P	C	N	P
Purslanes	C	C	C	C	C	C	C	N	C	N	C	P	P	C	N	P
Russian thistle	C	C	P	P	P	P	P	N	C	N	C	N	N	C	N	P
Shepherd's-purse	C	C	P	N	C	P	C	N	P	N	C	C	C	P	N	C
Sowthistles	P	C	C	P	C	N	C	N	P	N	C	C	C	P	N	P
Spotted spurge	C	C	C	P	P	P	P	N	C	N	C	N	N	C	N	P
Wild radish	C	C	P	P	C	N	C	N	C	N	C	C	P	C	N	C
Willowherb, panicle	C	P	N	P	C	--	--	N	P	N	P	--	N	N	N	P

NB = Non-bearing vineyards

CLET = clethodim (Prism)
DIQU = diquat (Reglone)
FLUA = fluazifop (Fusilade)
FLUM = flumioxazin (Chateau)
GLYP = glyphosate (Roundup, Touchdown)
HALO = halosulfuron (Sempra CA)
ISOX = isoxaben (Gallery T&V)
NAPR = napropamide (Devrinol)
ORYZ = oryzalin (Surflan)
OXYF = oxyfluorfen (Goal)
PARA = paraquat (Gramoxone)
PEND = pendimethalin (Prowl)
SETH = Sethoxydim (Poast)
THIA = thiazopyr (Visor)
2,4-D = (various trade names)

This is not an endorsement for of any trade names listed, nor does the omission of specific trade names reflect the view of the author. Please refer to your local dealer or chemical representative for specific herbicide products available.

This chart is not intended to be a recommendation for the use of herbicides. Refer to the appropriate label for application recommendations. Proper weed identification, timing, and accurate application are imperative for effective control. The information in this chart is tentative and may change as warranted. Always follow the label carefully when using herbicides. Kurt J. Hembree, Farm Advisor, Fresno County. Feb. 2005.

Chart 2. Susceptibility of Annual Grass and Perennial Weeds to Herbicides Registered in Pistachio Orchards in California

	Preemergence							Postemergence								
C = Control P = Partial control N = No control -- = No information	**FLUM**	**ISOX - NB**	**NAPR**	**ORYZ**	**OXYF**	**PEND - NB**	**THIA - NB**	**CLET - NB**	**DIQU - NB**	**FLUA - NB**	**GLYP**	**HALO**	**OXYF**	**PARA**	**SETH - NB**	**2,4-D**
Annual Grasses																
Annual bluegrass	C	N	C	C	P	C	C	C	P	N	C	N	N	P	N	N
Barnyardgrass	C	N	C	C	P	C	C	C	P	C	C	N	P	P	C	N
Bromegrasses	P	N	C	C	N	C	C	P	P	P	C	N	N	P	P	N
Canarygrass	P	N	C	C	P	C	C	C	P	C	C	N	N	P	C	N
Crabgrass, large	C	N	C	C	N	C	C	C	C	C	C	N	N	C	C	N
Fescues	P	N	C	C	N	C	P	P	P	P	C	N	N	P	P	N
Foxtails	C	N	C	C	N	C	C	C	C	C	C	N	N	C	C	N
Junglerice	C	N	C	C	P	C	C	C	P	C	C	N	P	P	C	N
Lovegrass	C	N	C	C	P	C	P	C	P	C	C	N	N	P	C	N
Ryegrass, Italian	P	N	C	C	N	C	C	C	P	C	C	N	N	P	C	N
Sandbur	C	N	C	P	N	C	C	C	P	C	C	N	N	P	C	N
Sprangletops	P	N	C	C	N	C	C	C	N	C	C	N	P	N	C	N
Wild barley	P	N	C	C	P	C	C	C	P	C	C	N	N	P	C	N
Wild oat	C	N	C	C	P	P	--	C	P	C	C	N	N	P	C	N
Witchgrass	P	N	C	C	P	C	--	C	P	C	C	N	N	P	C	N
Perennials (seedling)																
Bermudagrass	N	N	C	C	N	C	C	C	P	C	C	N	N	P	C	N
Dallisgrass	--	N	C	C	N	C	C	C	N	C	C	N	N	N	C	N
Johnsongrass	C	N	C	C	N	C	C	C	C	C	C	N	N	C	C	N
Field bindweed	--	C	N	P	N	P	C	N	P	N	C	N	N	P	N	P
Perennials (established)																
Bermudagrass	N	N	N	N	N	N	N	P	N	P	P	N	N	N	P	N
Dallisgrass	N	N	N	N	N	N	N	P	N	P	P	N	N	N	P	N
Johnsongrass	N	N	N	N	N	N	N	P	N	P	P	N	N	N	P	N
Field bindweed	N	P	N	N	N	N	P	N	N	N	P	N	N	N	N	N
Nutsedge, purple	N	N	N	N	N	N	P	N	N	N	P	C	N	P	N	N
Nutsedge, yellow	N	N	N	N	N	N	P	N	N	N	P	C	N	P	N	N

NB = Non-bearing vineyards

CLET = clethodim (Prism)
DIQU = diquat (Reglone)
FLUA = fluazifop (Fusilade)
FLUM = flumioxazin (Chateau)
GLYP = glyphosate (Roundup, Touchdown)
HALO = halosulfuron (Sempra CA)
ISOX = isoxaben (Gallery T&V)
NAPR = napropamide (Devrinol)
ORYZ = oryzalin (Surflan)
OXYF = oxyfluorfen (Goal)
PARA = paraquat (Gramoxone)
PEND = pendimethalin (Prowl)
SETH = Sethoxydim (Poast)
THIA = thiazopyr (Visor)
2,4-D = (various trade names)

This is not an endorsement for of any trade names listed, nor does the omission of specific trade names reflect the view of the author. Please refer to your local dealer or chemical representative for specific herbicide products available.

This chart is not intended to be a recommendation for the use of herbicides. Refer to the appropriate label for application recommendations. Proper weed identification, timing, and accurate application are imperative for effective control. The information in this chart is tentative and may change as warranted. Always follow the label carefully when using herbicides. Kurt J. Hembree, Farm Advisor, Fresno County. Feb. 2005.

Chart 3. Performance of Preemergence Herbicides in Pistachios in California

Herbicide	Conditions favoring effective weed control and crop safety
flumioxazin (Chateau)	Used at 0.188-0.38 lb a.i./acre in bearing and non-bearing orchards. Applied as a directed spray, being careful to avoid contact with young wood or foliage. Rainfall or irrigation of ¼ to ½" required within 21 to 28 days after treatment for activation. Can be tank-mixed with other residual herbicides for broader weed control and contact herbicides for burndown of weeds already present. Provides about 1 month residual control for each 2 oz/acre product used. Helps provide preemergence control of annual grasses, marestail, hairy fleabane, and other annual broadleaves.
isoxaben (Gallery T&V)	Used at 0.66-1.33 lb a.i./acre in non-bearing orchards only. It controls broadleaf weeds only. Application made after trees have completely settled into the soil. Rainfall or irrigation of at leas 0.5" needed within 21 days of treatment. Apply in at least 10 gal water/acre. PHI: 365 days..
napropamide (Devrinol)	Used at 4.0 lb a.i./acre in bearing and non-bearing orchards. Apply to the soil surface in 20 to 40 gal water/acre. Must be incorporated by rainfall or sprinkler irrigation within 7 days of treatment. Residual control is reduced under frequent, low-volume drip or micro-sprinkler irrigation. It should be combined with post-emergence herbicides if weeds are emerged. Residual period is 4-10 months.
oryzalin (Surflan)	Used at 2.0-6.0 lb a.i./acre in bearing and non-bearing orchards. Applied to soil free of leaves and other debris in 20 to 60 gal water/acre. Rainfall or irrigation of ¼ to 2" needed within 21 days of treatment. It is often combined with oxyfluorfen for broad-spectrum weed control. A post-emergence herbicide should be added if weeds are emerged. Applied at 6 lb a.i. for longer residual control. Chemigation is possible-refer to label. Residual period is 4 to 10 months.
oxyfluorfen (Goal)	Used at 1.2-2.l lb a.i./acre in bearing and non-bearing orchards. Applied in 20 to 60 gal water/acre. Rainfall or irrigation of at leas 3/4" needed within 21 to 28 days of treatment. Do not disturb the soil following treatment, or poor weed control will result. It is often combined with oryzalin for broad-spectrum weed control. Refer to the label for use period, cut-off dates, and other restrictions. Residual period is 4 to 10 months.
pendimethalin (Prowl)	Used at 2.0-4.0 lb a.i./acre in non-bearing orchards only. Applied in 20 to 40 gal water/acre to soil surface. Rainfall, irrigation, or mechanical incorporation required within 4 days of treatment. Directed at base of trees during dormant season, avoiding contact with foliage. PHI: 365 days.
thiazopyr (Visor)	Used at 0.5-1.0 lb a.i./acre in non-bearing orchards only. Applied in 20 to 40 gal water/acre. Applied at 0.5 lb a.i. in the fall and again in the late-winter for nutsedge control. Rainfall is needed within 21 days of treatment. Increased rainfall improves nutsedge control. Residual period is 5 to 8 months. PHI: 365 days.

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Numerous factors influence the performance of herbicides. The observations and comments in this table assume proper weed identification and accurate application and timing of treatments. Consult Charts 1 and 2 and the proper herbicide labels for the effectiveness of the registered herbicides to control your specific weeds. This table is not intended to be a recommendation for the use of herbicides. Always follow the label carefully when using herbicides. Kurt J. Hembree, Farm Advisor, Fresno County. Feb. 2005.

Chart 4. Performance of Postemergence Herbicides in Pistachios in California

Herbicide	Conditions favoring effective weed control and crop safety
clethodim (Prism)	Used at 0.09-0.25 lb a.i./acre in non-bearing orchards only. A crop oil concentrate (1% v/v) or a non-ionic surfactant (0.25% v/v) is added. Applied in 20 to 40 gal water/acre with thorough weed coverage. Gives selective control of annual grasses (except bromes and fescues) that are actively growing, before tillering, and not stressed. Repeat applications are required on perennials when their growth is according to label. PHI: 365 days.
diquat dibromide (Reglone)	Used at 0.375-0.5 lb a.i./acre in non-bearing orchards only. A non-ionic surfactant is added at 0.25% v/v. Applied in 20 to 60 gal water/acre with thorough weed coverage. Weeds are less than 4" tall. Control is improved during warm, dry weather. PHI: 365 days.
fluazifop-p-butyl (Fusilade)	Used at 0.25-0.375 lb a.i./acre in non-bearing orchards only. A crop oil concentrate (1% v/v) or a non-ionic surfactant (0.25% v/v) is added. Applied in 20 to 40 gal water/acre with thorough weed coverage. Gives selective control of annual grasses (except annual bluegrass, bromes, or fescues) that are actively growing, before tillering, and not stressed. Repeat treatments are required on perennials when their growth is according to label. PHI: 365 days.
glyphosate (Roundup, Touchdown)	Used at 0.4-4.0 lb a.i./acre in bearing and non-bearing orchards. Applied by ground with low-pressure, flat fan nozzles, a controlled droplet applicator, or a smart sprayer system. Adding ammonium sulfate at 5 to 10 lb/100 gal water may improve control. For annual weeds, use 1.0 lb a.i. in 3 to 40 gal water/acre. Apply to young, actively growing annual weeds or perennials when they are flowering. Some perennials may require highest label rate. Avoid drift onto green wood or foliage of trees or injury will result. Weeds should not be cultivated for 7 to 14 days after treatment to maximize control. Can be combined with low rates of oxyfluorfen for broader weed control, as well as combined with pre-emergence herbicides. PHI: 3 days.
halosulfuron (Sempra CA)	Used at 0.032-0.063 lb a.i./acre in bearing and non-bearing orchards. A non-ionic surfactant is added at 0.25% v/v. Trees must be completely settled in the soil before treatment. Avoid contact with tree foliage and roots, especially in soils that crack, or injury could result. Used where nutsedge is the main weed at the 4 to 5 leaf stage. Applied by ground with low-pressure, flat fan nozzles. Do not use a controlled droplet applicator. Sprayer is cleaned after application according to label. Clean soil is used for replants when previously treated. PHI: 1 day.
oxyfluorfen (Goal)	Used at 0.5-1.0 lb a.i./acre in bearing and non-bearing orchards. Applied during dormant period or following bloom (according to label directions) to weeds at the 4-leaf stage or sooner. Combined with glyphosate or other post-emergence herbicides to control specific weeds.
paraquat (Gramoxone)	Used at 0.3-0.9 lb a.i./acre in bearing and non-bearing orchards. A non-ionic surfactant is added at 0.5% v/v. Applied in 20 to 60 gal water/acre with thorough weed coverage. Weeds are less than 4" tall. Repeat applications needed as new growth occurs. A restricted herbicide, requiring a permit from the county agricultural commissioner for purchase and use. PHI: 7 days.
sethoxydim (Poast)	Used at 0.28-0.47 lb a.i./acre in non-bearing orchards only. A crop oil concentrate is added at 1% v/v. Applied in 20 to 40 gal water/acre with thorough weed coverage. Gives selective control of annual grasses (except annual bluegrass, bromes, or fescues) that are actively growing, before tillering, and not stressed. Repeat treatments are required on perennials when their growth is according to label. PHI: 365 days.
2,4-D amine (Weedaxe)	Used at 1.0-1.4 lb a.i./acre in bearing and non-bearing trees that are at least 1 year old. Selective on small, vigorous broadleaf weeds. Applications made on sandy soil, when windy, when trees are in bloom, or under hot conditions can result in injury. Do not make application before an irrigation or rainfall or injury could result. Sprayer is cleaned after application according to label.

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Numerous factors influence the performance of herbicides. The observations and comments in this table assume proper weed identification and accurate application and timing of treatments. Consult Charts 1 and 2 and the proper herbicide labels for the effectiveness of the registered herbicides to control your specific weeds. This table is not intended to be a recommendation for the use of herbicides. Always follow the label carefully when using herbicides. Kurt J. Hembree, Farm Advisor, Fresno County. Feb. 2005.