Project No. 89-U1 - Vegetation Management in Almond Orchards

Project Leader: Mr. Bill B. Fischer
Fresno County Farm Advisor
1720 South Maple Avenue
Fresno, CA 93702
(209) 488-3285

Cooperating Personnel: David Goldhamer, Kearney Agricultural Center

Objectives: (1) Study the performance and selectivity of newly introduced herbicides, combinations and sequential applications of herbicides in almond orchards. (2) Evaluate the feasibility of applying herbicides through microsprinklers, to be conducted at the Kearney Agricultural Center. (3) compare the performance of glufosinate, glyphosate and two new formulations of glyphosate for postemergence control of weeds and their effectiveness in controlling the growth of the vegetation in the middles.

Interpretive Summary:

Almond growers using low volume emitters to irrigate their orchards find it difficult to maintain the control of weeds in the areas wetted by the emitters. It was demonstrated in earlier studies that more effective and longer lasting weed control can be obtained under low volume microsprinklers than where continuous (daily) drip emitters are used. However, even in microsprinkler irrigated orchards, effective weed control cannot be maintained with the application of soil persistent herbicides during the dormant period.

To maintain effective weed control through the summer months, the injection of herbicides through low volume emitters was investigated. Applying herbicides through continuously (daily) run drip emitters failed to provide effective weed control in the wetted areas. Injecting the same herbicides into low volume microsprinklers provided much more effective control.

During 1988 and 1989 several herbicides were injected into the irrigation system using microsprinklers. Mission and Nonpareil varieties were planted in the trial area.

Soil persistent herbicides were applied with a conventional sprayer during the winter to obtain weed control in a five-foot strip of soil on each side of the planted row, inside and outside of the areas wetted by the emitters. During May, when weed seeds began to germinate in the areas wetted by the emitters, herbicides were injected with a positive displacement pump into the system below the filters.

The most effective control was obtained with Endurance (prodiamine). Goal (oxyfluorfen) also provided good control, however, it did not provide as effective control of spotted spurge as Endurance. Solicam (norflurazon) effectively controlled the weeds but its residual effectiveness was shortved. Surflan (oryzalin) provided good control of the susceptible weeds, however, its spectrum was not as broad as Endurance, Goal or Solicam. Devrinol (napropamide) provided only short-lived control in the wetted areas.

The weed control obtained with these herbicides applied with conventional boom sprayer was comparable to the control obtained with injection into the microsprinklers.

The feasibility of injecting herbicides into the irrigation system, where low volume spray emitters (but not continuous drip emitters) are used, was demonstrated. Additional studies are needed to determine the rate and/or frequency of injection needed to maintain seasonal weed control.

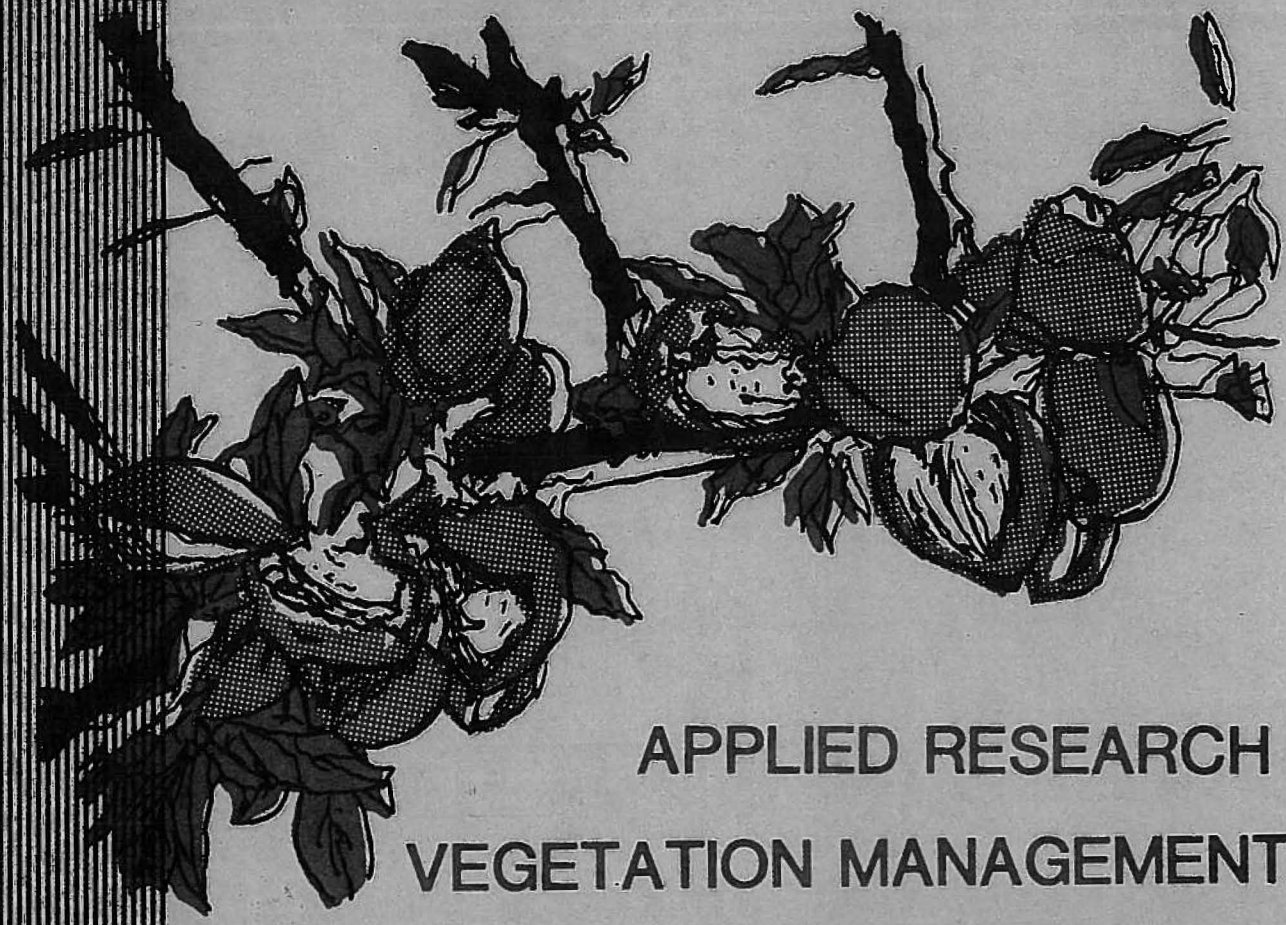
Postemergence Trial

Ignite (glufosinate) compared very favorably with Roundup (glyphosate) for the control of annual weeds. At 1.0 to 2.0 pounds of active ingredient per acre it provided a broader spectrum of weed control than was obtained with Roundup at rates up to 1.0 pound active ingredient per acre. However, Ignite killed the weeds more rapidly, especially during cold temperatures.

Two formulations of Roundup were evaluated for the control of yellow nutsedge in a newly planted orchard. At comparable rates of active ingredient, MON 144-5 did not provide more effective control than Roundup.

Regardless of the rates applied, regrowth occurred and retreatments were required at monthly intervals. Nutsedge can be effectively controlled, possibly eradicated, if they are not allowed to produce new, mature tubers. This can be accomplished by treating the nutsedge plants with Roundup or MSMA when they have 5 to 7 leaves.

Runcina VOL. 40



APPLIED RESEARCH of
VEGETATION MANAGEMENT in

ALMOND ORCHARDS

A Progress Report

University of California Cooperative Extension
Fresno County

COOPERATIVE EXTENSION
UNIVERSITY OF CALIFORNIA

COUNTY OF FRESNO
FARM AND HOME ADVISORS OFFICE

1720 SOUTH MAPLE AVENUE
FRESNO, CALIFORNIA 93702

ACKNOWLEDGEMENTS

This progress report is a summary of information gathered in applied research studies conducted in cooperation with many Fresno County almond growers since 1959. Without their interest, encouragement, and cooperation our studies could not have been conducted.

I am indebted to Dr. A. H. Lange, U.C. Extension Weed Scientist, Emeritus, for his cooperation in some of the trials, and for maintaining the long-term experiments during my sabbatical leaves. My colleagues and former colleagues, Todd Brown, Marvin Gerdts, Joe Connell and several field research assistants were generous with their time and their labor. I am grateful for their expertise.

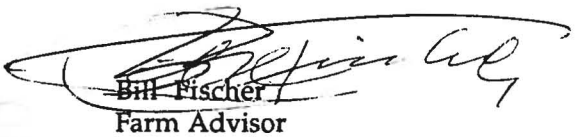
The studies evaluating the performance of herbicides under low volume emitters, still in progress, is being conducted in cooperation with Dr. D. Goldhamer, U.C. Extension Soils and Water Specialist, at Kearney Agricultural Center. His cooperation and assistance is indispensable.

The grant received from the California Almond Board to pursue our studies is greatly appreciated and enabled me to prepare this progress report. I am grateful for the editorial assistance of Heidi Seney, Editor, U.C. DANR Publications and Jane Waugh Fischer, and to Harold Kempen for his critcal comments.

The secretarial labor of Nancy Shaw and the skill of Jim Caughell in printing and assembling this report are praiseworthy.

The herbicides evaluated for vegetation management in almond orchards, listed on Pages 20 and 21 were supplied gratis by their respective manufacturers. We are grateful for their generosity.

This progress report does not contain recommendations for the use of herbicides.



Bill Fischer
Farm Advisor

TELEPHONE (209) 488-3285

TABLE OF CONTENTS

VEGETATION MANAGEMENT IN ALMOND ORCHARDS

Bill B. Fischer, Kurt J. Hembree, and Mark W. Freeman*

Almonds have been an important source of food for humans from ancient times. It is the oldest, most extensively grown, and nutritionally concentrated nut crop. Almonds can be utilized in many ways.

Almond trees were first introduced into California from Spain and Mexico by early missionaries. Later, in the 1840s, trees were introduced to the New England states, but production wasn't successful because of the severe climate. The almond industry in California can be traced to the trees brought to the state in 1843 from the east coast.

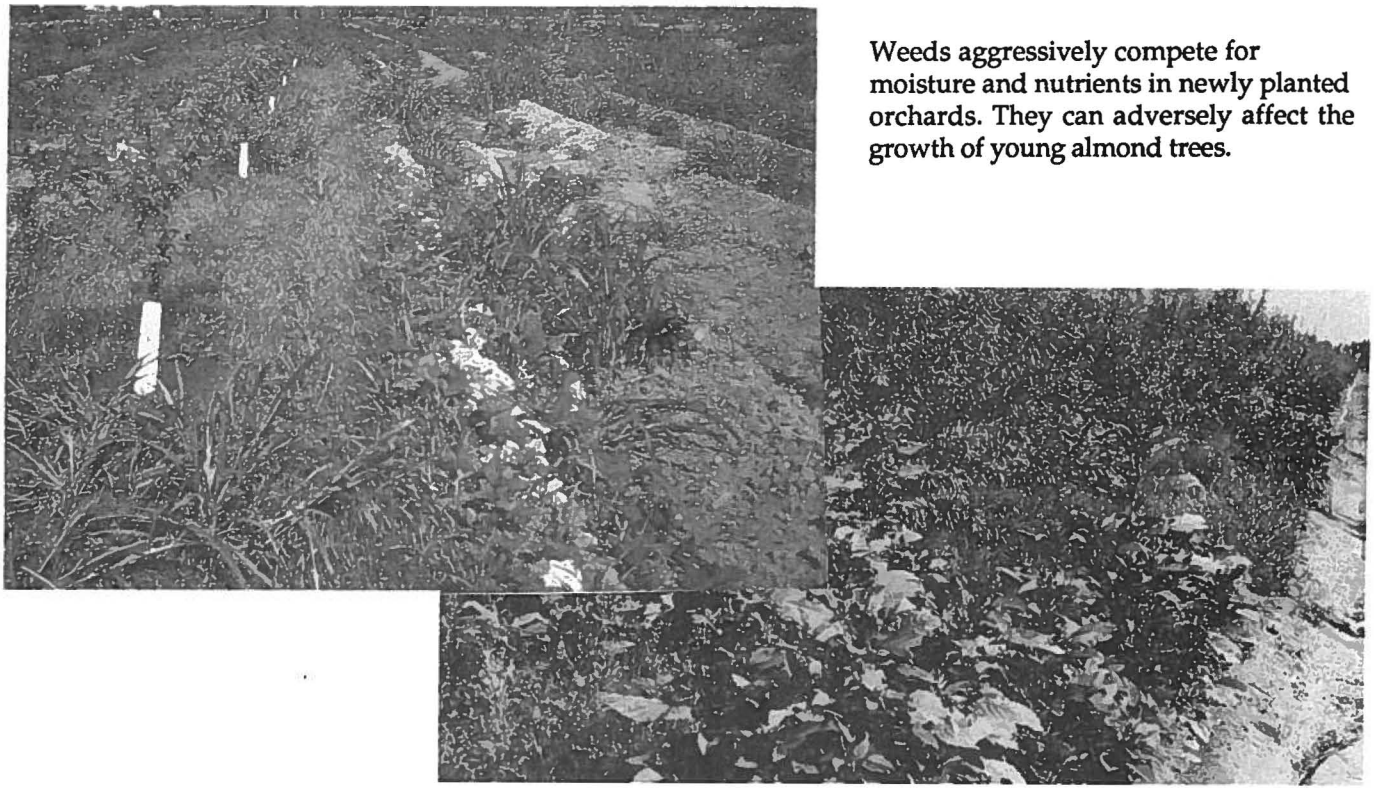
Today, there are in excess of 423,000 acres of almonds in California, 3.7 percent of which are new plantings or nonbearing. Value of the crop in 1989 exceeded $600 million. New acreage is still being established and the most rapidly expanding area of production is the San Joaquin Valley.

Why Vegetation Management?

Almonds are grown on different types of soil under varied irrigation and orchard floor management practices. To maintain sustainably profitable production, it is essential that unwanted competing vegetation (weeds) is effectively controlled. A vigorously growing pigweed, lambsquarter, or horseweed will use as much water and nutrients as a newly planted tree. Therefore, to insure the rapid uniform growth of young trees in newly planted orchards, it is essential to control competitive weeds.

---

*Fischer and Freeman are Farm Advisors, Hembree is Research Assistant; all on the staff of the University of California Cooperative Extension, Fresno County



Weeds aggressively compete for moisture and nutrients in newly planted orchards. They can adversely affect the growth of young almond trees.

In mature orchards, controlling unwanted vegetation:

- Minimizes competition for the available water and nutrients.
- Insures the efficient management and harvesting of the crop.
- Reduces frost hazard in early spring; uncontrolled vegetation can result in lower orchard floor temperatures in late winter and early spring.
- Prevents flowering of weeds at the time the trees are in bloom to minimize competition for pollinators.
- Assists with the performance of essential cultural practices such as application of pesticides, pruning, and harvesting.
- Facilitates the efficient use of low volume emitters.

Vegetation management is a system of environmentally sound husbandry utilizing all available knowledge and tools to manage orchards free of unwanted competing vegetation to produce almonds profitably in a sustainable manner.

It is nearly impossible and very costly to prepare the orchard floor for mechanical harvest in the almond orchards pictured on this page. In a well-planned vegetation management system, the preparation of the orchard floor for harvest would require less time, less energy, and could be accomplished at a much lower cost.

Applied Research Studies

Since 1958, many replicated applied research trials were conducted in almond orchards in Fresno County to evaluate a large number of herbicides and mechanical devices for the control of the unwanted vegetation. The studies were conducted on several varieties of almonds growing on soils that varied in texture from loamy sand to clay loam and contained less than 1 percent organic matter. Irrigation methods ranged from basin-flood, furrow, and sprinkler to low-volume drip emitters and microsprinklers. Some trials were maintained for many years (the longest, 10) in which the same herbicides were applied every year.

The purpose of this progress report is to summarize results of the trials, observations of many commercial orchards, and consultations with growers during the past 30 years. Many of the herbicides evaluated are not registered or labeled for use in almond orchards. However, a significant amount of information has been accumulated about the performance of soil-persistent and foliar-applied herbicides that are presently labeled for use in almond orchards. Four charts summarize the susceptibility of commonly occurring weeds in orchards in the central San Joaquin Valley and the performance of the labeled herbicides.

Is There an Ideal Method of Orchard Floor Management?

It would be convenient if one could outline an ideal method of almond orchard floor management. Unfortunately, there is no such method, but there is a best method that can be developed for any one orchard.

A large array of tools, mechanical and chemical, are available to enable each almond grower to develop the most effective and most economical method of vegetation management within the limit of his or her resources. Important factors to consider in planning the orchard floor and vegetation management systems are:

- Topography or the lay of the land
- Soil type, its texture and structure

- Permeability of the soil to water
- Salinity of the soil
- Irrigation method to be used
- Availability and competence of labor
- Cost and availability of fuel, power and equipment
- Availability and cost of herbicides
- Method of harvest
- Accessibility of orchard during rainy periods to perform essential cultural practices
- Microclimate, especially as it relates to frost hazard
- Knowledge of the vegetation (weeds) present

Effective vegetation management has to be a well planned, integral part of the total orchard management system.

In well planned vegetation management systems, the preparation of the orchard floor for mechanical harvest is relatively simple.

Tillage Versus Nontillage

In the past, unwanted vegetation on the orchard floor was controlled by repeated cross-disking. Cultivating in one direction destroyed 85 to 90 percent of the weeds but, to obtain control in a narrow strip within the tree row, the entire orchard floor had to be tilled a second time. In many orchards, repeated cultivations created soil compaction, reduced water infiltration and caused slow decline in productivity. Working close to the trees with heavy equipment resulted in bruising and injuring the trees. Through the wounds, crown rotting and crown gall organisms could readily invade the trees.

The introduction of herbicides offered more options in orchard floor management. Strip nontillage, whereby a narrow strip of soil is treated with a soil-persistent, selective herbicide, was rapidly adopted because the need for cross-tillage was eliminated and soil manipulation (disking and plowing) was reduced by 45 to 50 percent. Strip non-tillage, among other benefits, minimized soil compaction and hastened the adoption of low volume emitters for the application of irrigation water.

Complete nontillage management, where herbicides are used on a narrow 4- to 8-foot strip of soil in the tree row, and in the middles (the area between the tree rows), vegetation be controlled with repeated mowing or flailing, has been a logical step. Complete control of the vegetation with soil-persistent and foliar-applied herbicides has become feasible with such herbicides such as Goal (oxyfluorfen), Surflan (oryzalin), Solicam (norflurazon), Roundup (glyphosate), and so on.

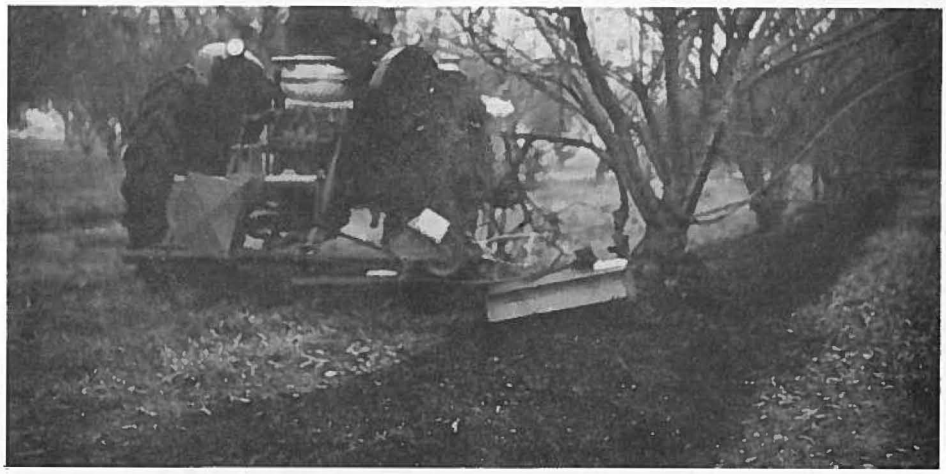
Minimum Tillage or Nontillage Without Chemicals

Herbicides are not indispensable for limited tillage or nontillage management of almond orchards. Such mechanical tools as mowers and rotary tillers, equipped with hydraulic tripping mechanisms, can be used to control vegetation in a 2- to 6-foot strip of soil within the tree row. The middles can be mowed or flailed to control the resident vegetation or the cover crop.

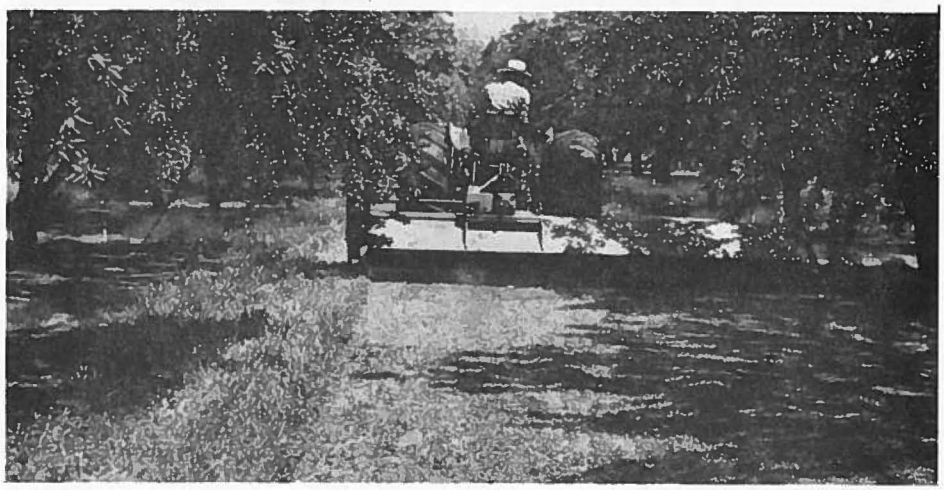
In orchards irrigated with low-volume emitters, the distribution lines have to be hung on the tree (or suspended) high enough to allow sufficient clearance for the operation of the tillers or mowers under the emitters.

The effectiveness of mowing and tilling is relatively short-lived; they have to be repeated fairly frequently. To minimize excessive growth and its demand for water and to limit the accumulation of trash. Succulent weeds decompose more readily than older plants with fibrous or woody stems. Excessive vegetation and trash can also interfere with preparations for mechanical harvesting.

Effective vegetation management can be accomplished, without the use of chemicals, with tools and equipment such as illustrated by the pictures on the left.



Mechanical tools equipped with tripping mechanisms can be used to till a narrow strip of soil in the tree row. The vegetation growing in the middles can be controlled with repeated mowing or flailing.

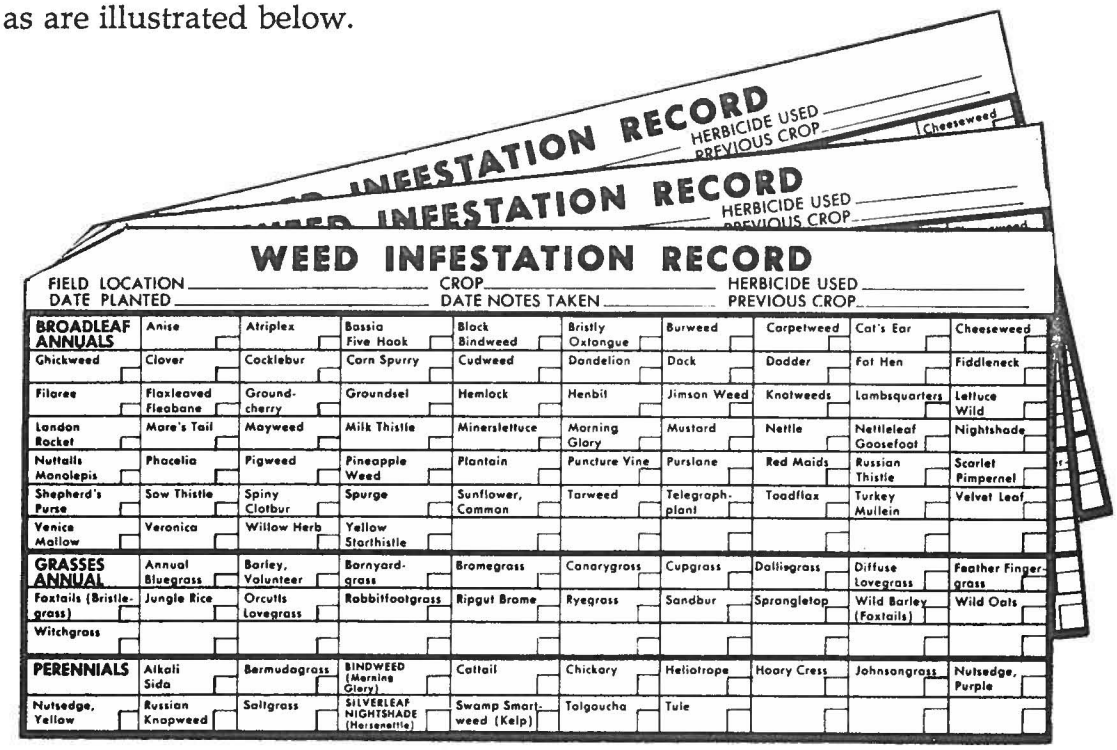


Minimum Tillage or Nontillage with Chemicals

Almond growers have a choice of a number of soil-persistent and foliar-applied contact and translocated herbicides to effectively manage vegetation in newly planted established orchards.

Herbicide use can be limited to narrow strips in the tree rows, confined to small areas around the trunk of trees, or the entire orchard floor can be treated.

However, as illustrated in Tables 1 through 5, no single herbicide can control all the weeds found infesting almond orchards. Therefore, combinations and/or sequential applications of herbicides are required to maintain adequate seasonal control. Selecting the most effective and most economical combinations hinges on proper identification and keeping records of weed distribution. Repeated use of the same herbicide can cause shifts in the weed population. This can be recognized in time only if records are kept of the weed infestation. A simple, widely used method is on cards, such as are illustrated below.



WEED INFESTATION RECORD

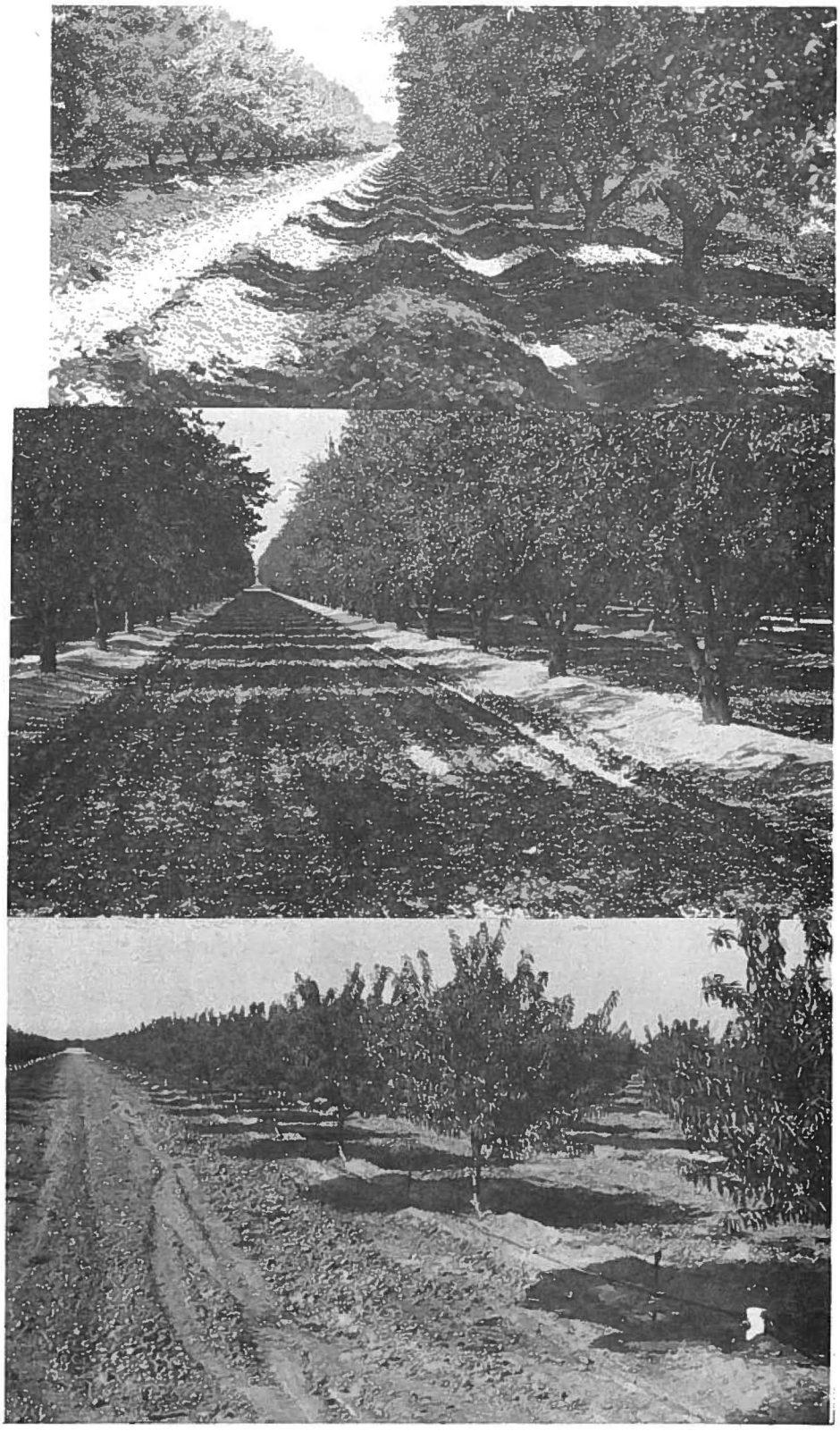
FIELD LOCATION _____ CROP _____ HERBICIDE USED _____
DATE PLANTED _____ DATE NOTES TAKEN _____ PREVIOUS CROP _____

BROADLEAF ANNUALS	Anise	Atriplex	Bassia Five Hook	Black Bindweed	Bristly Oxtongue	Burweed	Carpetweed	Cat's Ear	Cheeseweed
Chickweed	Clover	Cocklebur	Corn Spurry	Cudweed	Dandelion	Dock	Dodder	Fat Hen	Fiddleneck
Filaree	Flaxleaved Fleabane	Ground-cherry	Groundsel	Hemlock	Henbit	Jimson Weed	Knotweeds	Lambsquarters	Lettuce Wild
London Rocket	Mare's Tail	Mayweed	Milk Thistle	Minerslettuce	Morning Glory	Mustard	Nettle	Nettleleaf Goosefoot	Nightshade
Nuttalls Monolepis	Phacelia	Pigweed	Pineapple Weed	Plantain	Puncture Vine	Purslane	Red Maids	Russian Thistle	Scarlet Pimpernel
Shepherd's Purse	Sow Thistle	Spiny Clotbur	Spurge	Sunflower, Common	Tarweed	Telegraph-plant	Toadflax	Turkey Mullein	Velvet Leaf
Venice Mallow	Veronica	Willow Herb	Yellow Starthistle						
GRASSES ANNUAL	Annual Bluegrass	Barley, Volunteer	Barnyard-grass	Bromegrass	Canarygrass	Cupgrass	Dallisgrass	Diffuse Lovegrass	Feather Finger-grass
Foxtails (Bristle-grass)	Jungle Rice	Orcutts Lovegrass	Rabbitfootgrass	Ripgut Brome	Ryegrass	Sandbur	Sprangletop	Wild Barley (Foxtails)	Wild Oats
Witchgrass									
PERENNIALS	Alkali Sida	Bermudagrass	BINDWEED (Morning Glory)	Cattail	Chickory	Heliotrope	Hoary Cress	Johnsongrass	Nutsedge, Purple
Nutsedge, Yellow	Russian Knapweed	Saltgrass	SILVERLEAF NIGHTSHADE (Horsenettle)	Swamp Smart-weed (Kelp)	Tolgoucha	Tule			

Weed infestation can be easily recorded on cards such as these. They are available for the asking from Farm Advisors and PCA's.

The pictures on the following pages illustrate widely used methods of orchard floor management that are widely used in the central San Joaquin Valley.

STRIP NONTILLAGE MANAGEMENT



Soil persistent herbicides are applied in the tree row during the rainy season. The middles are disked periodically and furrows are made for irrigation.

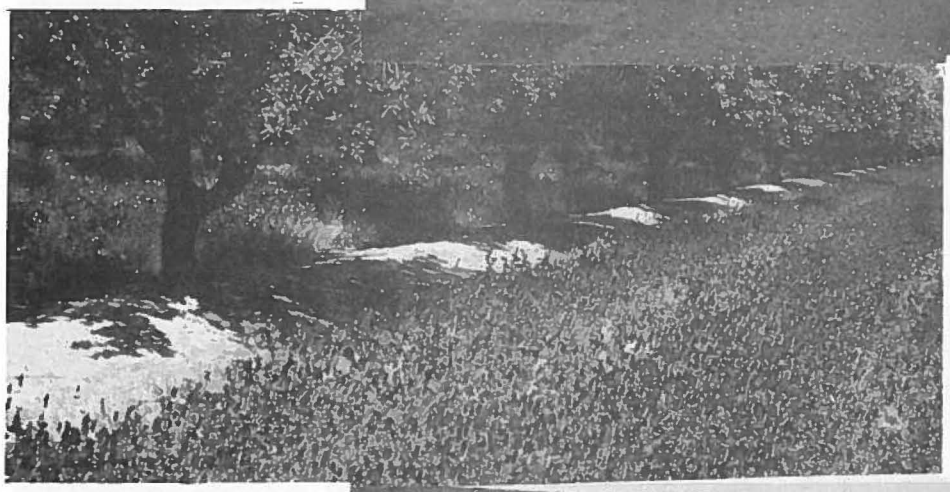
Tillage reduced 45 to 50 percent with the application of herbicides in the tree row and the middles are disked periodically and flood irrigated. Irrigation water is not applied over the herbicide treated areas.

Herbicides are used in a strip of soil, where the microjet emitters are placed. The middles require only one or two light diskings because the area is not wetted and the growth of the vegetation is sparse.

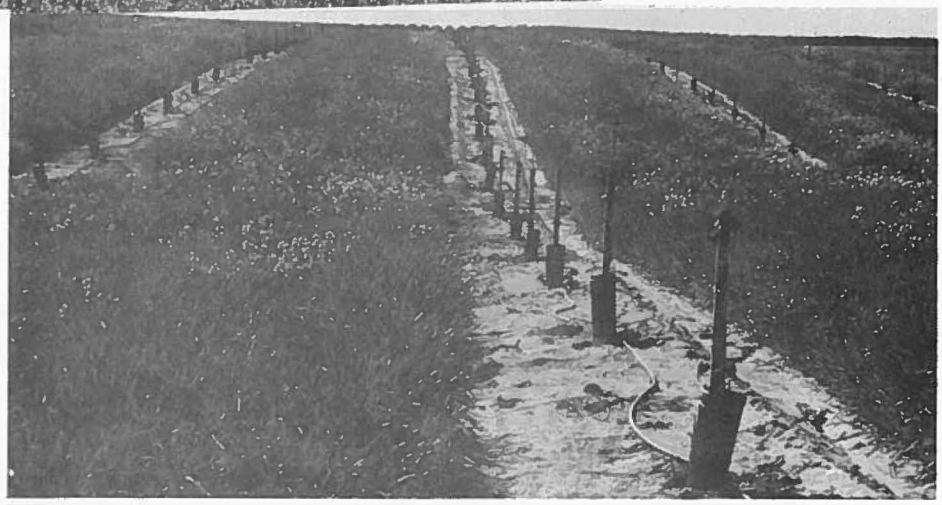
NONTILLAGE MANAGEMENT WITH MINIMUM USE OF HERBICIDES

Soil persistent herbicides applied on a narrow strip of soil, only 1/8th of the orchard floor treated. The resident vegetation is mowed periodically. Basin flood irrigation is used but no water is applied on the berm.

Soil persistent herbicides applied around the base of the trees. The vegetation on the rest of the orchard floor is controlled by mowing, as illustrated on the right.

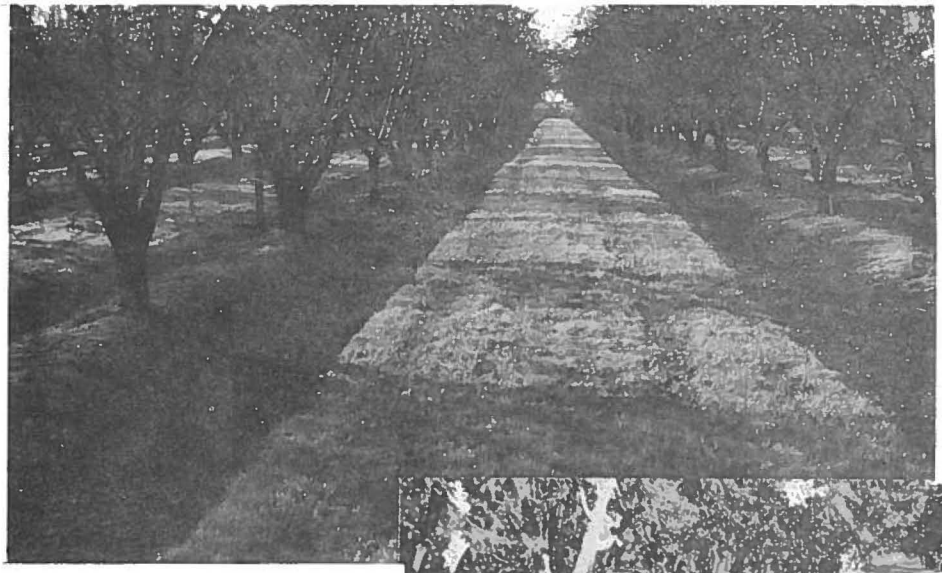


Strip nontillage management where herbicides are used only in a narrow strip of soil. Cover crops such as clovers, shown on the left, and others, can be planted and mowed periodically.



Strip nontillage, as shown on the right, is desirable on soils subject to erosion. The weeds or, more correctly, the resident vegetation, can be controlled by repeated mowing.

NONTILLAGE MANAGEMENT WITH HERBICIDES



Soil persistent herbicides applied during the rainy period in the tree row. The resident vegetation in the middles is treated periodically with foliar applied systemic or contact herbicides. The orchard is basin-flood irrigated.

Illustrated on the right is an almond orchard that has not been cultivated for more than 10 years. The entire orchard floor is treated every year with soil persistent herbicides. The few surviving weeds are treated with a systemic herbicide.

Nontillage management in the microsprinkler irrigated almond orchard, pictured on the left, is accomplished with the use of soil persistent herbicides in the tree row and foliar applied herbicides in the middles. Since no irrigation water is applied in the middles, the weed growth is sparse.

The Safe Use of Herbicides

Among the management practices that have the most significant effect on the performance, selectivity and residual activity of herbicides is the method of irrigation. The herbicides that are registered for use in orchards are organic compounds. They are degraded in or on the soil by different methods, the most important being: photodecomposition, chemical degradation, hydrolysis and breakdown through the activities of microbiological organisms. Therefore, climatic conditions, cultural and irrigation practices favoring these processes will shorten the effectiveness and residual activity of herbicides.

Another very important factor to keep in mind is that selectivity of many herbicides is not physiological but it is achieved through placement. As long as they are kept in the surface 6 to 12 inches of soil and out of the area where roots are actively growing, they are safe to use. Hence, the method and frequency of irrigation can significantly influence the leaching of herbicides, their selectivities, their persistence and their degradation. In California, almond orchards are supplied with water through:

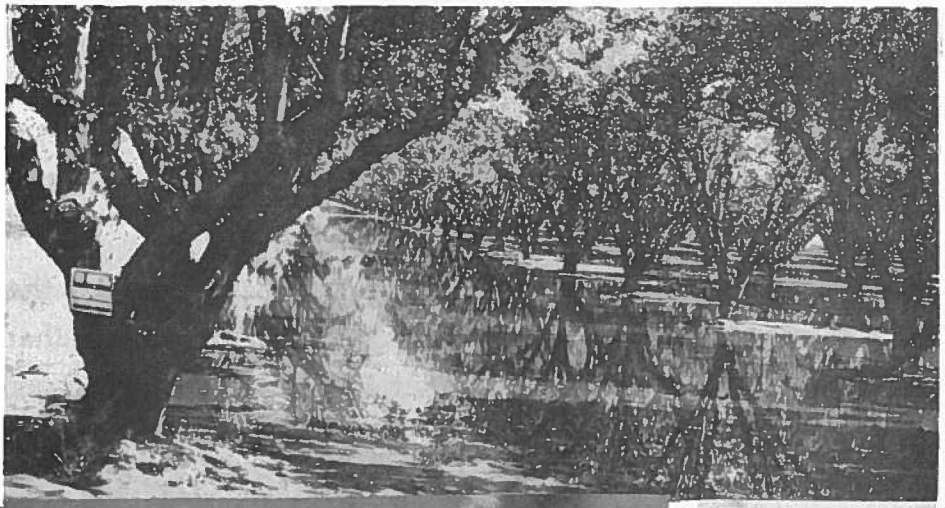
- Furrow irrigation
- Basin flood irrigation
- Sprinkler irrigation
- Low-volume drip irrigation
- Microsprinklers and microjets

Herbicides are available that can be used effectively and safely under any one of these methods. However, their behavior on different soils and methods of irrigation must be considered in their selection.

In orchards where water is applied frequently through low volume emitters, it is very difficult to maintain effective control in the continuously wetted areas. Therefore, the method of orchard floor management and the irrigation practices employed will often dictate the selection of the herbicides, the frequency and rate of their application.

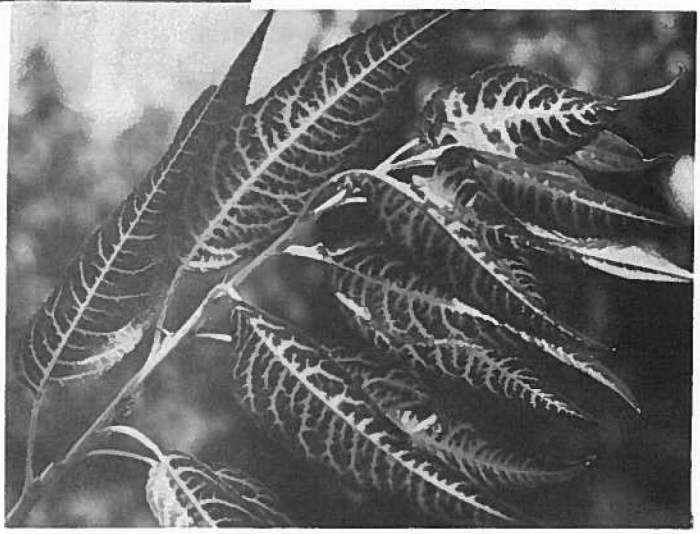
Herbicides must be used according to the directions printed on their respective labels. The weed susceptibility charts included in this progress report and the chart summarizing the performance of herbicides in the central San Joaquin Valley can serve as a guide in their selection.

CONSEQUENCES OF POOR IRRIGATION



Several herbicides labeled for use in almond orchards can cause symptoms where irrigation water is poorly managed, as shown on the left. Water piles up at the end of the rows flooding the herbicide treated area.

Symptoms caused by dichlobenil (Norosac - Casoron) is yellowing and burning around the margins of the leaves.



Norflurazon (Solicam) symptoms are veinal chlorosis, bleaching of the leaf stalks and of the immature stems.

Simazine (Princep, Caliber 90, etc.) causes chlorosis (yellowing) of the leaf blade between the veins. The veins remain green, except in severe symptoms when the entire leaf can become chlorotic and necrotic (dies).

VEGETATION MANAGEMENT UNDER LOW VOLUME EMITTERS

During the past decade, the use of low volume emitters (drip, microsprinklers, microjets, foggers, misters) became an attractive alternative to conventional (furrow, flood, sprinkler) irrigation methods. This can be attributed to increasing demand for water, its rising cost coupled with increasing cost of energy and labor.

The primary advantage of using low volume emitters is the potential to improve the uniformity of water application. A serious drawback is the vigorous weed growth that occurs in areas wetted by emitters. Vegetation around emitters interfere with proper monitoring of their performance. The residual activity of herbicides (weed control) in frequently wetted soil is often much shorter lived than with conventional low-frequency irrigation systems.

Studies were conducted evaluating the performance of numerous herbicides under furrow irrigation, where no irrigation water was applied over the herbicide-treated area, drip irrigation, and under microsprinklers. As expected, the most effective control was obtained in the furrow-irrigated areas. It was also clearly demonstrated that more effective and longer residual weed control can be obtained under low-volume sprinklers than with drip emitters (Tables 6 and 7). This is presumably due to the more rapid microbiological and chemical (hydrolysis) degradation of herbicides in the continually wetted soil associated with high-frequency drip irrigation.

To maintain weed control around the emitters, foliar-applied contact or translocated herbicides are used. Since they don't provide residual control, repeated applications (4 to 10) are required.

"Can herbicides be injected into low volume irrigation systems to maintain effective weed control in the frequently wetted areas around the emitters?" A logical question asked by many growers.

Applying Herbicides in Irrigation Water

The first herbicide applied in irrigation water (referred to as chemigation or herbigation) in almond orchards was Eptam (EPTC), used primarily to control summer annual weeds in preparation of the orchard floor for harvest.

Eptam has relatively short residual activity and has to be applied at least 14 days before harvest. It can be applied on the surface of the soil before the last irrigation prior to harvest, or it can be injected into the irrigation water. Eptam does not control established weeds; therefore, it can be used most effectively in orchards where the soil is disked, rolled, and irrigated in preparation for harvest.

Symptoms of phytotoxicity were observed in areas where irrigation water, into which Eptam was injected, accumulated (ponded), mainly at the end of the rows.

Applying Herbicides through Low-Volume Emitters

Injection of herbicides into "drip" irrigation systems was evaluated by many investigators. The results obtained were disappointing. Regardless of the herbicides used, effective weed control was limited to the area a few inches around the emitters where free water was present. The wetted front beyond the ponded free water became heavily infested with weeds, as illustrated.

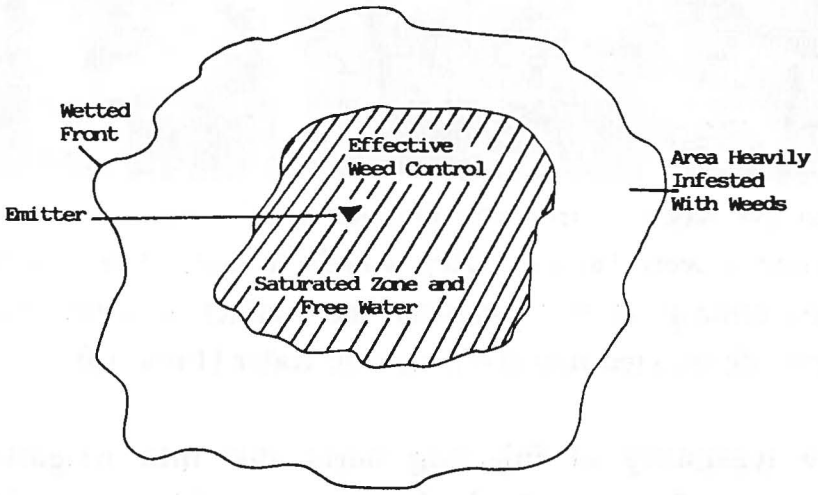


Fig. 1. The pattern of weed control and weed-infested area under drip irrigation where herbicides are injected into the water.

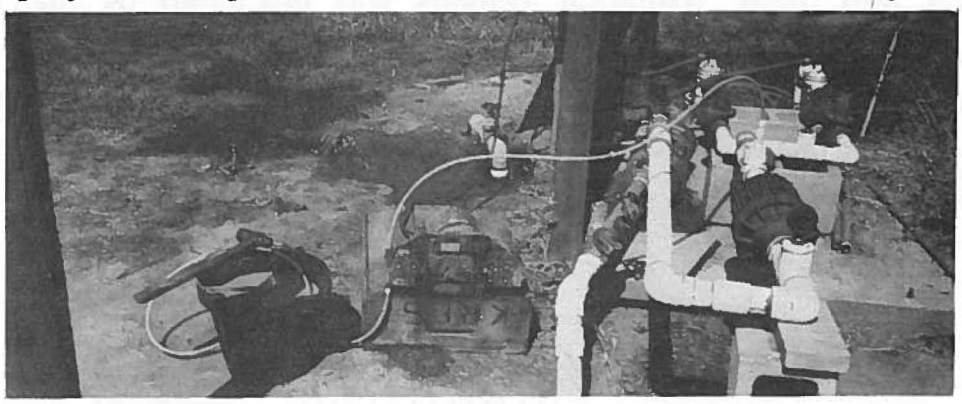
In microsprinkler irrigated orchards, water is applied less frequently (twice a week) than the daily application used with drip emitters. Microsprinklers wet a larger area of the soil, and between irrigation the wetted area dries; therefore, the degradation of herbicides is slower. In recent studies conducted at the Kearney Agricultural Center it was demonstrated that more effective weed control can be obtained with herbicides applied through microsprinklers than through drip emitters. This is due to more uniform distribution of the herbicide over the wetted area. More recently, soil persistent herbicides were applied during the dormant period, with conventional boom sprayers, to obtain weed control in a strip of soil (10 feet wide), centered on the

tree row. Microsprinklers were used twice a week for irrigation. Each microsprinkler wetted an area 12 feet in diameter.

In May, when some weed seeds started germinating in the areas wetted by the emitters, the performance of the following herbicides were evaluated by injecting them into the irrigation water:

Devrinol	4.0 lbai/A	Ronstar	3.0 lbai/A
Endurance	2.0 and 4.0 lbai/A	Solicam	2.0 lbai/A
Goal	1.6 lbai/A	Surflan	4.0 lbai/A

The same day, some of the same herbicides were applied with a conventional boom sprayer to compare their relative effectiveness in controlling the weeds.



Herbicides were injected into the low volume microsprinkler irrigation system with a positive displacement pump (as shown on on the left). Note that the herbicide is being injected after the water passed through the filters.

Effective weed control was obtained with several of the herbicides. Spotted spurge and cudweed were the surviving weeds in several treatments. The conventional spray application provided somewhat more effective control as was obtained with the same herbicide injected into the irrigation water (Table 10).

The feasibility of injecting herbicides into irrigation water applied through microsprinklers was clearly demonstrated. However, additional studies are needed to sort out which herbicide(s) will provide the most effective control, which ones are safe to use and at what rate, and whether low rates applied several times will provide more effective control than a single application at a higher rate.

Conclusions

Almond growers in California have an array of tools, mechanical and chemical, that can enable them to develop orchard floor and vegetation management systems suitable for meeting their economic, aesthetic, and philosophical needs.

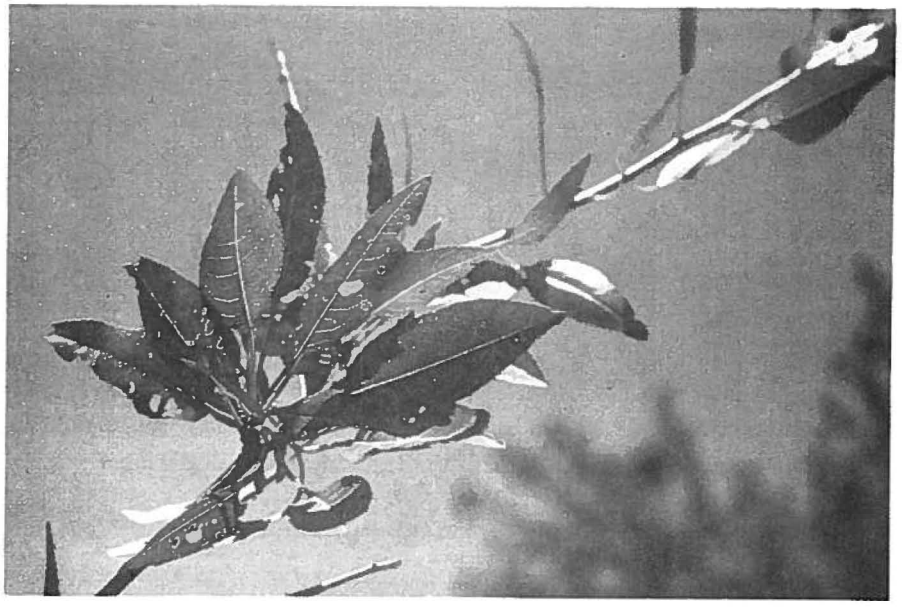
It is essential to emphasize that vegetation can be managed or controlled without using herbicides. No weed has ever developed resistance to the metal blade, whether on the end of a stick or fashioned into disks or rotary tillers; this cannot be said of herbicides. However, their effectiveness is short lived and these methods have to be used repeatedly.

With the intelligent use of chemical tools, nearly unlimited methods of orchard floor management systems can be developed. The vegetation, or weeds, can be very effectively controlled at a lower cost than with repeated tillage. With minimum use of herbicides in narrow strips or in limited areas around the trunk of trees, orchardists can entirely eliminate the need for soil manipulation or tillage.

The cover crops or the resident vegetation (native vegetation, weeds) can be controlled with repeated mowing, flailing, or with low rates of foliar applied herbicides such as Gramoxone, Roundup, and Roundup plus Goal. To accomplish this, the importance of proper selection and timely application of herbicides cannot be repeated too often. This, in turn, depends on proper identification of the resident vegetation (weeds).

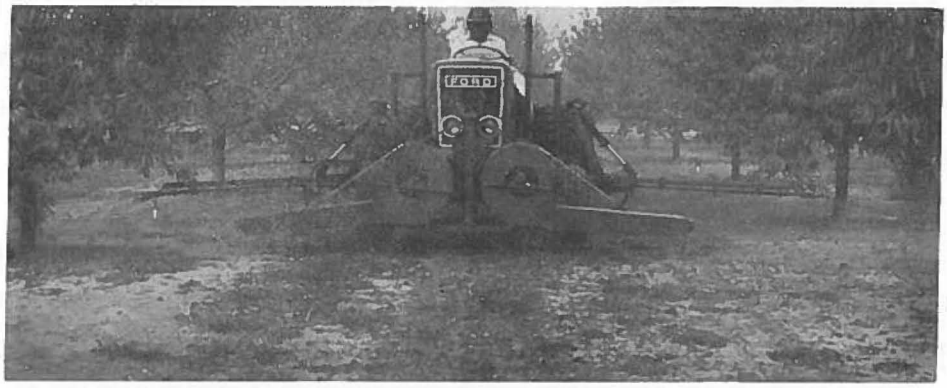
By using the weed susceptibility charts included in this progress report, and by following the instructions on the labels of herbicides, almond growers can develop effective, economical vegetation management systems.

Proper Timing of Herbicide Application Is Essential to Control The Vegetation and Maintain Selectivity

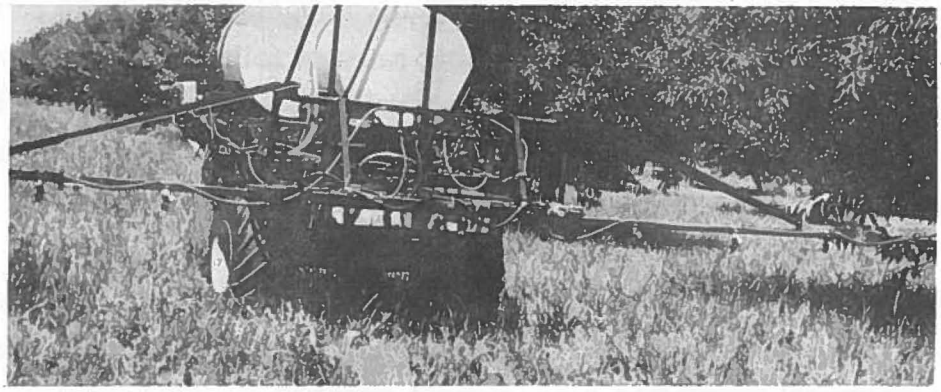


Symptoms, such as shown on the left, were caused by oxyfluorfen (Goal) applied early spring.

ONLY THE APPLICATOR CAN MAKE AN HERBICIDE EFFECTIVE AND SAFE



Excessive leaves or other trash can be removed with blowers such as pictured above. This can ensure even distribution of the herbicide on the soil surface.



Care should be exercised in spraying foliar applied herbicides to avoid drift. Use low pressure with LP nozzle tips.

Above left: symptoms caused by glyphosate (Roundup) drift during application with low volume controlled droplet applicator (CDA).

On the right: symptoms caused by translocated glyphosate from previous year's application.

CHART 1 SUSCEPTIBILITY OF ANNUAL WEEDS TO HERBICIDES EVALUATED IN ALMOND ORCHARDS

SOIL APPLIED RESIDUAL HERBICIDES

▓ = EFFECTIVELY CONTROLLED
▨ = PARTIALLY OR ERRATICALLY CONTROLLED
□ = NOT CONTROLLED

BROADLEAF WEEDS		CASORON NOROSAC dichlobenil	DEVRINOL napropamide	EPTAM EPTC	GOAL oxyfluorfen	PRINCEP simazine	PROWL NB* pendimethalin	SOLICAM norflurazon	SURFLAN oryzalin	TREFLAN trifluralin
CHEESEWEED	W + S	▨	▨		▓	▨		▨		
CHICKWEED	S	▓	▓	▓	▨	▓	▓	▓	▓	▓
COCKLEBUR	S	▓	▓		▨	▓		▓		
CUDWEED	W + S	▓	▓	▨		▓		▓		
CLOVERS	W	▓	▨		▓	▓		▓		
FIDDLENECK	W	▓	▓	▓	▓	▓	▓	▓	▓	▓
FILAREE	W	▨	▓	▨	▓		▨	▨		▨
FLAXLEAF FLEABANE	W + S	▨			▨	▓		▨		
GOOSEFOOT	S	▓	▓	▓	▓	▓	▓	▓	▓	▓
GROUNDCHERRY	S	▓		▓	▓	▓		▓		
GROUNDSEL	W	▓	▓	▓	▓	▓		▨		
HENBIT	W	▓	▨	▓	▓	▓	▨	▓	▨	▨
HORSEWEED	W + S	▨		▓	▨	▓		▨		
KNOTWEED	W + S	▨	▓	▨	▓	▓	▓	▓	▓	▓
LAMBSQUARTER	S	▓	▓	▓	▓	▓	▓	▨	▓	▓
LONDON ROCKET	W	▨	▨	▨	▓	▓		▓		
MINERS LETTUCE	W	▓	▓	▨	▓	▓	▓	▓	▓	▓
MUSTARD	W	▨	▨		▓	▓		▓		
NETTLE	W + S	▓	▨	▓	▓	▓	▨	▓	▨	▨
NIGHTSHADE	S	▓		▓	▓	▓		▓		
PIGWEED	S	▓	▓	▓	▓	▓	▓	▨	▓	▓
PINEAPPLEWEED	W	▓	▓	▨	▓	▓		▓		
PRICKLY LETTUCE	W + S	▓	▓	▓	▓	▓		▨		
PUNCTUREVINE	S	▨	▨		▨		▨	▓	▨	▨
PURSLANE	S	▓	▓	▓	▓	▓	▓	▨	▓	▓
RED MAIDS	W	▓		▓	▓	▓	▓	▓	▓	▓
RUSSIAN THISTLE	S	▨	▨	▨	▨	▓	▨	▓	▨	▨
SHEPHERD'S PURSE	W	▓		▨	▓	▓		▓		
SOWTHISTLE	W + S	▓	▓	▓	▓	▓	▓	▨	▓	▓
SPURGE	S	▓			▨			▨	▨	
SPEEDWELL	S	▓	▓		▓	▓	▨	▓	▨	▨
WILD RADISH	W		▨		▓	▓		▓		

W = WINTER ANNUAL
S = SUMMER ANNUAL

GRASSY WEEDS										
ANNUAL BLUEGRASS	W	▨	▓	▓	▨	▨	▓	▓	▓	▓
BARNYARDGRASS	S		▓	▓	▨	▨	▓	▨	▓	▓
BRISTLEGRASS	S		▓	▓			▓	▨	▓	▓
BROMEGRASS	W	▨	▓	▓	▨		▓	▓	▓	▓
CANARYGRASS	W	▨	▓	▓	▨	▨	▓	▓	▓	▓
CRABGRASS	S	▨	▓	▓	▨		▓	▨	▓	▓
FESCUES	W	▨	▓	▓	▨	▨	▓	▓	▓	▓
LOVEGRASS	S		▓	▓	▨		▓	▨	▓	▓
RABBITFOOTGRASS	W	▨	▓	▓	▨	▨	▓	▓	▓	▓
RYEGRASS	W	▨	▓	▓	▨	▨	▓	▓	▓	▓
SANDBUR	S		▓	▓			▓	▨	▓	▓
WILD BARLEY	W	▨	▓	▓	▨	▨	▓	▓	▓	▓
WILD OATS	W	▨	▓	▓	▨		▓	▓	▨	▨
WITCHGRASS	S		▓	▓	▨		▓	▨	▓	▓

NB* nonbearing only

This chart is not a recommendation for the use of herbicides. Before using herbicides, please check the label whether they are registered and their rate of application. Proper timing and accurate application is imperative. The information in this chart is tentative, based on

CHART 2 SUSCEPTIBILITY OF ANNUAL WEEDS TO HERBICIDES REGISTERED FOR USE IN ALMOND ORCHARDS

= EFFECTIVELY CONTROLLED

= PARTIALLY OR ERRATICALLY CONTROLLED

= NOT CONTROLLED

FOLIAR APPLIED HERBICIDES

BROADLEAF WEEDS		FUSILADE 2000 NB* fluazifop butyl	GRAMOXONE paraquat	MSMA NB* MFG*	POAST NB* sethoxydim	ROUNDUP glyphosate	2,4-D MFG*
CHEESEWEED	W + S						
CHICKWEED	S						
COCKLEBUR	S						
CUDWEED	W + S						
CLOVERS	W						
FIDDLENECK	W						
FILAREE	W						
FLAXLEAF FLEABANE	W + S						
GOOSEFOOT	S						
GROUNDCHERRY	S						
GROUNDSEL	W						
HENBIT	W						
HORSEWEED	W + S						
KNOTWEED	W + S						
LAMBSQUARTER	S						
LONDON ROCKET	W						
MINERS LETTUCE	W						
MUSTARD	W						
NETTLE	W + S						
NIGHTSHADE	S						
PIGWEED	S						
PINEAPPLEWEED	W						
PRICKLY LETTUCE	W + S						
PUNCTUREVINE	S						
PURSLANE	S						
RED MAIDS	W						
RUSSIAN THISTLE	S						
SHEPHERD'S PURSE	W						
SOWTHISTLE	W + S						
SPURGE	S						
SPEEDWELL	S						
WILD RADISH	W						
GRASSY WEEDS							
ANNUAL BLUEGRASS	W						
BARNYARDGRASS	S						
BRISTLEGRASS	S						
BROMEGRASS	W						
CANARYGRASS	W						
CRABGRASS	S						
FESCUES	W						
LOVEGRASS	S						
RABBITSFOOTGRASS	W						
RYEGRASS	W						
SANDBUR	S						
WILD BARLEY	W						
WILD OATS	W						
WITCHGRASS	S						

W = WINTER ANNUAL
S = SUMMER ANNUAL

NB* = Nonbearing only MFG* = Various trade names

This chart is not a recommendation for the use of herbicides Before using herbicides, please check the label whether they are registered and their rate of application. Proper timing and application is imperative. The information in this chart is tentative, based on experiments

Chart 3 - PERFORMANCE OF SOIL APPLIED HERBICIDES IN ALMOND ORCHARDS IN FRESNO COUNTY

Numerous factors influence the performance of herbicides. The following observations and comments assume accurate and timely application. Consult the weed susceptibility charts for the effectiveness of the herbicides to control specific weeds. B. Fischer

Herbicide Soil Applied	Conditions Resulting In Effective Control	Conditions Resulting In Poor Control Or Injury
CASORAN NOROSAC dichlobenil	Incorporated into the soil on the berms in furrow or basin flood irrigated orchards. Provided control of some perennials.	Applied on the soil surface without incorporation. Symptoms of phytotoxicity observed where irrigation water applied over treated area.
DEVRINOL napropamide	When rainfall occurred or irrigated within 7 to 10 days of application, or incorporated into the soil soon after application.	Not leached or incorporated into the soil within 7 to 10 days after application. Provided short lived control under low volume frequent irrigation. Weeds were emerged at the time of treatment. Trashy conditions.
EPTAM EPTC	Sprayed on the soil surface or injected into the water during the last irrigation prior to harvest. Applied before germination of the seeds.	Applied on cloddy soil. Weeds established at time of treatment. Applied on the soil surface and not irrigated within hours. Caused injury in poorly leveled orchards in areas where water accumulated.
GOAL oxyfluorfen	Most persistent herbicide under low volume frequent irrigation. Provided post and pre-emergence activity on young weeds. Where cheeseweed was present.	Soil disturbed following its application. Caused foliar symptoms on lower leaves when applied early spring.
PROWL pendimethalin	IN NON-BEARING ORCHARDS ONLY When rainfall occurs or irrigation water applied over the treated area within 7 to 10 days.	Rainfall did not occur or irrigation water not applied within two weeks of treatment. Weeds were emerged at the time of treatment.
SIMAZINE *various trade names*	Applied on the berms. Applied at very low rates (0.5 to 1.0 lbai/A) in combination with other herbicides.	Mission variety is susceptible when irrigation water applied over treated area. Under microsprinklers, even 1.0 lbai/A caused symptoms on Mission, but not on other varieties.
SOLICAM norflurazon	Most effective and longest residual control obtained on berms or where irrigation water was not applied over the treated area. Provides supression and control of nutsedge. When applied in combination with Simazine or Goal.	Readily leached by irrigation water. Short-lived control under low volume frequent irrigation. Symptoms observed in orchards where irrigation water applied over treated area.
SURFLAN oryzalin	When rainfall occurs within 10 to 14 days following its application on areas free of trash. Incorporated into the soil with tillers soon after application.	If rainfall did not occur, no irrigation applied over treated area or not incorporated within 14 to 21days after treatment. Orchard floor covered with leaves or trashy.
TREFLAN trifluralin	Incorporated into the soil to a depth of 2 to 4 inches within 2 to 3 hours of application. Most effectively used prior to planting in newly planted orchards.	Not incorporated within a short time after application. Deep incorporation may temporarily retard the growth of the newly planted trees.

(Continued on next page)

Chart 4 - PERFORMANCE OF FOLIAGE APPLIED HERBICIDES IN ALMOND ORCHARDS IN FRESNO COUNTY

Herbicide Foliar Applied	Conditions Resulting In Effective Control	Conditions Resulting In Poor Control Or Injury
FUSILADE 2000 fluazifop-p	IN NON-BEARING ORCHARDS ONLY Applied on vigorously growing annual (except annual bluegrass) and perennial grasses in combination with paraffin based adjuvants. Repeated (2 to 3) applications on perennial grasses in newly planted orchards. Selective on all broadleaf plants.	Applied on grasses stressed for moisture. Repeat applications not made to control perennial grasses. Annual bluegrass the predominant grass. Adequate paraffin based adjuvant not used.
GRAMOXONE paraquat	Applied on plants in their seedling (2- to 6-leaf) stage of growth. Compatible in tank mixes with other herbicides.	Applied on plants beyond their seedling stage. Plants with waxy, hairy and mealy surfaces often not killed. Foliage of trees as well as immature bark can be injured. It is a Category I pesticide. Permit and protective clothing required.
MSMA *various trade names*	IN NON-BEARING ORCHARDS ONLY Applied repeatedly on vigorously growing johnsongrass. Yellow nutsedge having 4 to 6 leaves and the regrowth is treated repeatedly.	Treatment was not repeated. Does not control bermudagrass and broad-leaf weeds. Injury resulted when sprayed on the foliage and on immature bark.
POAST sethoxydim	IN NON-BEARING ORCHARDS ONLY Applied on vigorously growing annual (except annual bluegrass) and perennial grasses in combination with paraffin based adjuvants. Repeated (2 to 3) applications on perennial grasses in newly planted orchards. Selective on all broadleaf plants.	Applied on grasses stressed for moisture. Repeat applications not made to control perennial grasses. Annual bluegrass the predominant grass. Adequate paraffin based adjuvant not used.
ROUNDUP glyphosate	Applied postemergence on vigorously growing annual and perennial weeds. Used at low rates it arrested the growth of the vegetation without killing them. Applied on nutsedge having 5 to 6 leaves. Combination with soil persistent herbicides to control emerged weeds. Repeated applications to control the growth of the vegetation around low volume emitters.	Plants droughty or not growing vigorously when treated. Used at low rates resulted in rapid shift in population of plant species. Careless use under windy conditions resulting in drift has caused severe symptoms. Painted on tree stumps caused serious injury as a result of translocation through root graft. Sprayed on immature, young tree trunks and branches of the trees caused injury and severe gumming.
2,4-D *various trade names*	Applied on young broadleaf weeds when growing vigorously.	Some weed species become tolerant as they grow beyond their seedling or rosette stage. Can be used only from Oct. 15 to Mar. 15 and permit is required. Spraying the trees or drift of the herbicide can cause injury.

NOTE: *Please consult the weed susceptibility charts for the use of effective combinations or sequential applications. Follow label directions, especially, pay close attention to restrictions on timing of application as related to harvest. B. Fischer.*

The following tables were selected from a large number of evaluations in many trials to serve as a reference for some observations reported in the narrative section.

For additional information, please contact the senior author of this progress report.

Herbicides Evaluated Alone and In Combinations For Vegetation Management in Almond Orchards in Fresno County

Trade Name	Common Name	Manufacturer
FOLIAR APPLIED		
Casoron-Norosac	dichlobenil	Uniroyal
Cotoran	fluometuron	CIBA-Geigy
Dacthal	DCPA	SDS Biotech
Devrinol	napropamide	ICI Americas
Dual	metolachlor	CIBA-Geigy
Endurance	prodiamine	Sandoz
Enide	diphenamid	Nor-Am
Eptam	EPTC	ICI Americas
Goal	oxyfluorfen	Rohm and Haas
Igran	terbutryn	CIBA-Geigy
Karmex	diuron	DuPont
Kerb	pronamide	Rohm and Haas
Lorox	linuron	DuPont
Planavin	nitralin	Shell
Princep	simazine	CIBA-Geigy
Probe	methazole	Sandoz
Prowl	pendimethalin	American Cyanamid
Ronstar	oxadiazon	Rhone-Poulenc
Sinbar	terbacil	DuPont
Solicam	norflurazon	Sandoz
Surflan	oryzalin	Elanco
Treflan	trifluralin	Elanco
FOLIAR APPLIED		
Amitrol	amitrole	Rhone-Poulenc
Dalapon	dalapon	United Agri-Products
Dinitro	dinoseb	Dow
Fusilade 2000	fluazifop-p	ICI Americas
Gramoxone	paraquat	ICI Americas
Ignite	glufosinate	Hoescht-Roussel
MSMA	MSMA	several
Poast	sethoxydim	BASF
Roundup	glyphosate	Monsanto
2,4-D	2,4-D	several

TABLE 1 - EFFECT OF REPEATED APPLICATIONS OF HERBICIDES ON WEED CONTROL IN ALMOND ORCHARDS

500, 425, 146, 10, 76-5

Soil Type: Hanford sandy loam
Herbicides Applied: 1/19/75, 1/26/76, 1/6/77, 1/17/78, 1/5/79, 12/28/79, 1/5/81, 11/30/81, 1/10/83, 12/3/83

Irrigation Method: Sprinkler
Plot Size: 10' x 48' - Reps. 4
Evaluated: See below

	Herbicide	lbai/A	WEED CONTROL EVALUATIONS 3/28/84 Percent Weed Cont.	3/28/84 Weeds Present*	5/29/84 Percent Weed Cont.	5/29/84 Weeds Present*	7/11/84 Percent Weed Cont.	7/11/84 Weeds Present*
A	Surflan Princep	4.0 0.5	100	—	98	Hw,Ns	99	Hw
B	Devrinol Princep	4.0 0.5	100	—	97	Hw,Ns, Pr,Ru	93	C,Cd,Cp, La,Hr,Pl, Pr
C	Endurance Princep	2.0 0.5	100	—	98	Pr	99	Pr
D	Endurance	4.0	100	—	97	Pr	99	Pr
E	Endurance	8.0	98	Pr	89	Pr	99	Pr
F	Goal	2.0	95	A,Chw, Hw,Pr	93	Hw,Ns	99	C,Hw,Ru
G	Goal	4.0	99	Hw	88	Hw,Ns	99	Hw
H	Goal	8.0	70	M,Pr	92	Hw,L	99	Hw
J	Devrinol Goal	4.0 2.0	99	Pr	98	Hw,L,Pr	98	Hw
K	Surflan Goal	4.0 2.0	100	—	97	Hw	99	Hw
L	Prowl Princep	4.0 0.5	100	—	97	Pl	88	C,Cd,Cp, Hw,La,Pl, Pr,Ru
M	Devrinol Princep	4.0 1.0	100	—	97	Hw	99	C,Cd,Cp, Hw,La, Pl,Pr,Ru
N	Surflan Princep	4.0 1.0	100	—	99	Hw	99	Cd,Hw
P	Princep Ronstar	0.5 3.0	100	—	99	Hw	97	C,Cp,Hw
Q	Untreated	—	30	A,Cd,Chw, F,Hw,O, Pr,R,Sp	63	C,Chw,Cp, M,Ns,Pr	84	C,Cd,Chw, Hw,Pl,Pr, Ru

Remarks: No evidence of phytotoxicity observed.

*Weeds Present: A = annual bluegrass; C = crabgrass, Cd = cudweed; Chw = chickweed, Cp = cupgrass; F = filaree; Hw = horseweed; L = flaxleaf fleabane; La = lambsquarter; Ns = nutsedge; O = common groundsel; Pl = purslane; Pr = primrose; R = redmaid; Ru = Russian thistle; Sp = shepherd's purse.

NOTE: All weeds in all plots were sprayed with Roundup after each evaluation.

TABLE 2 - EFFECT OF SOIL PERSISTENT HERBICIDES ON WEED CONTROL IN ALMOND ORCHARDS
CW22, A-36, H-8, 10, 75-14

Soil Type: Hanford sandy loam
Trees Planted: Spring, 1969
Herbicides Applied: 1/4/71, 1/5/72, 12/9/72, 1/4/74, 1/75
Irrigation Method: Solid Set Sprinkler
Plot Size: 7' x 48' - Reps. 4
Evaluated: 5/15/75

Herbicide	lbai/A	WEED CONTROL EVALUATIONS 3/28/84 Percent Broadleaf Control	Percent Grass Control	Weeds Present*
A Devrinol	4.0	49	93	F,Hw,R,Sp,Y
B Devrinol	8.0	58	93	Hw,R,Sp,Y
C Surflan	4.0	60	90	F,Hw,Sp,Y
D Surflan	8.0	60	90	F,Hw,Sp,Y
E Endurance	4.0	60	78	F,Hw,Sp,Y
F Endurance	8.0	63	90	F,Hw,R,Sp,Y
G Devrinol Kerb	4.0 2.0	80	100	F,Hw,Sp,Y
H Devrinol Kerb	4.0 4.0	76	100	Hw,Sp,Y
J Surflan Kerb	4.0 4.0	73	93	F,Hw,R,Sp,Y
K Surflan Kerb	4.0 4.0	86	100	F,Hw,Y
L Devrinol Solicam	4.0 2.0	90	100	F,Y
M Devrinol Solicam	4.0 4.0	93	100	F
N Devrinol Princep	4.0 0.5	100	100	—
P Surflan Princep	4.0 0.5	100	100	—
Q Surflan Ronstar	4.0 2.0	83	98	Hw,Y
R Surflan Ronstar	4.0 4.0	98	98	Hw,Y

Remarks: No evidence of phytotoxicity observed. Hericides applied in 1050 cc of water per plot with a CO_2 sprayer. Paraquat was added at 0.5 lbai/A to control the emerged weeds.

*Weeds Present: F = filaree; Hw = horseweed; R = redmaid; Sp = shepherd's purse; Y = pineappleweed.

TABLE 3 - EFFECT OF SOIL PERSISTENT HERBICIDES ON WEED CONTROL IN ALMOND ORCHARDS
500, 425, 146, 10, 76-5

Soil Type: Hanford sandy loam
Herbicides Applied: 1/26/76, 1/6/77, 1/17/78, 1/5/79, 12/28/79
Irrigation Method: Solid Set Sprinkler
Plot Size: 10' x 48' - Reps. 4
Evaluated: 4/7/80, 7/29/80

			WEED CONTROL EVALUATIONS			
			3/28/80		7/29/80	
Herbicide		lbai/A	Percent Weed Control	Weeds Present*	Percent Weed Control	Weeds Present*
A	Surflan Princep	4.0 0.5	95	Cu,F	87	Hw,Pr
B	Devrinol Princep	4.0 0.5	85	F,Hw,Pr	68	F,Hw,Pr
C	Endurance Princep	2.0 0.5	92	F	87	F,Hw,Pr
D	Endurance	4.0	90	Cu,F,Hw	98	Cu,F,Hw
E	Endurance	8.0	90	Cu,F	97	Cu,Pr
F	Goal	2.0	75	A,Chw,Cu,Hw,Pr	71	Cu,Hw,Pr,X
G	Goal	4.0	90	A,Chw,Cu,Hw	95	Cu,Pr,X
H	Goal	8.0	97	A,Chw,Cu	98	A,Chw,Cu
J	Devrinol Goal	4.0 2.0	90	Hr,Pr,Wr	70	Hw,Pr
K	Surflan Goal	4.0 2.0	95	Hw,Pr,Wr	87	Hw,Pr
L	Prowl Princep	4.0 0.5	92	Hw,Pr,Wr	95	Hw,Pr
M	Devrinol Princep	4.0 1.0	85	F,Hw,Pr	75	A,Cu,Pr
N	Surflan Princep	4.0 1.0	97	F	92	Pr
P	Princep Ronstar	0.5 4.0	80	F,Hw,Wr	92	Hw,Pr
Q	Untreated	—	0	A,Chw,Cu,Hw,M	77	Cu,Hw,Pr,Wr,X

Remarks: No evidence of phytotoxicity was observed.

*Weeds Present: A = annual bluegrass; Chw = chickweed; Cu = cudweed; F = filaree; Hw = horseweed; Pr = primrose; Wr = wild radish; X = grasses.

TABLE 4 - EFFECT OF SOIL APPLIED HERBICIDE IN A SPRINKLER IRRIGATED ALMOND ORCHARD

Soil Type: Hanford sandy loam
Evaluated: Winter annuals: March 12, 1973
Summer annuals: June 1, 1973
Irrigation Method: Sprinkler solid set
Herbicides Applied: January 14, 1971
Retreated: January 15, 1973

Herbicide	lbai/A	Winter Annual Percent Control	Weeds Present	Percent Summer Annual Weed Control and Phytotoxicity Evaluation 1/ Overall Wd. Con.	Pig-weed	Lamb's-quarter	Purs-lane	Horse-weed	Russian Thistle	Willow Herb	Annual Grasses	Phytoto-xicity
TRIAL A												
A Devrinol	4.0	96	H,R	67	100	100	42r	77	97	92	90	0
B Devrinol	8.0	98	R,S	77	100	100	60r	85	100	95	95	0
C Ronstar	2.0	87	P,R,S	22	95	7	7	20	55	70	37	0
D Ronstar	4.0	80	A,L,P,R, S,W	17	87	0	37	42	10	100	47	0
E Solicam	2.0	100		32	60	85	0	62	57	65	75	0
F Solicam	4.0	100		50	35	90	25	65	77	100	80	3.0
G Surflan	2.0	98	P,R	92	100	100	100	90	97	100	100	0
Igran	1.0											
H Surflan	4.0	97	F	97	100	100	100	97	100	100	100	0.2
Igran	2.0											
J Ronstar	2.0	92	P,R,S	92	100	100	95	95	100	100	100	0
Surflan	2.0											
K Devrinol	2.0	97	R,S	80	95	100	67r	95	100	100	100	0
Princep	0.5											
L Ronstar	2.0	82	A,P,R,S	90	100	100	87	80	100	95	100	0
Planavin	2.0											
M Untreated	---	0	A,F,G,L, P,R,S,W	0	0	0	0	0	0	0	0	0
TRIAL B												
N Devrinol	4.0	96	A,G,P, S,W	77	100	100	80r	67	85	100	92	0
Igran	1.0											
P Devrinol	4.0	92	A,F,G, P,R,S	80	90	100	67r	65	77	100	87	0
Solicam	1.0											
Q Ronstar	2.0	80	A,M,R, S,W	72	100	100	60r	57	87	90	100	0
Devrinol	4.0											
R Casoron	2.0	82	A,M,R,S	85	97	100	77r	77	80	95	100	0
Devrinol	4.0											
S Probe	4.0	100	----	95	97	100	97	90	95	100	100	0

r = weeds present retarded in growth 1/ Evaluations based on a 0 to 10 scale: 0 = no phytotoxicity, 10 = severe phytotoxicity

REMARKS: Trial area is sprinkler irrigated at weekly intervals. The weed population (especially purslane) most numerous near the permanently set sprinklers.

TABLE 5 - EFFECT OF REPEATED APPLICATION OF HERBICIDES ON WEED CONTROL IN AN ALMOND ORCHARD

CW 22, A 36, H 8, 10, 69-10

Soil Type: Atwater sandy loam
Varieties: Mission, Kapareil, Nonpareil
Treated: 1/9/69
Retreated: 11/29/69, 12/10/70, 1/20/72, 11/28/72

Plot Size: 6' x 44'
Irrigation Method: Basin Flood*
Evaluated: 3/30/73

Herbicide	lbai/A	PERCENT WEED CONTROL - AVERAGE OF THREE REPLICATIONS									
		Overall Wd.Cont.	Common Groundsel	Red maids	Smooth Catsear	Filaree	Chick-weed	Pineap-pleweed	Shepherd's Purse	Grasses	Popcorn Flower
A Sinbar	1.0	97	95	85	86	100	100	100	100	100	97
B Sinbar	2.0	96	95	95	95	97	100	100	100	97	97
C Sinbar	4.0	98	97	100	97	100	97	100	100	100	100
D Princep	2.0	100	100	100	100	100	100	100	100	100	100
E Princep	4.0	100	100	100	100	100	100	100	100	100	100
F Karmex	2.0	100	100	100	100	100	100	100	100	100	100
G Sinbar + Karmex	1.0 + 1.0	100	100	100	100	100	100	100	100	100	100
H Sinbar + Planavin	1.0 + 2.0	100	100	100	100	100	100	100	100	100	100
J Princep + Planavin	1.0 + 2.0	96	100	100	100	90	100	100	100	100	100
K Princep + Planavin	2.0 + 2.0	97	100	100	100	95	100	100	100	100	100
L Devrinol	2.0	43	100	100	100	100	100	100	56	100	20
M Devrinol	4.0	70	100	100	96	100	100	100	90	100	16
N Devrinol	8.0	66	100	100	100	100	100	100	90	100	26
X Untreated	---	0	0	0	0	0	0	0	0	0	0

Remarks: No irrigation water, except rainfall, was applied over the herbicide treated areas.

TABLE 6 - THE PERFORMANCE OF HERBICIDES UNDER TWO TYPES OF LOW VOLUME EMITTERS IN DECIDUOUS ORCHARD

500, 425, 115, 110, 82-1

Location: Kearney Agricultural Center
Soil Type: Hanford sandy loam
Herbicides Applied: 3/4/82, 1/17/83, 1/25/84, 1/2/85
Type of Emitters: D = drip, M = mist

Varieties: Mission and Nonpareil
Plot Size: 8' x 68', Reps. 3
Trees Planted: 2/10/82

		PERCENT WEED CONTROL, 4/24/85					
		DRIP			MIST*		
		Wetted Area		Weeds**	Wetted Area		Weeds**
Herbicide	lbai/A	Inside	Outside	Present	Inside	Outside	Present
A Devrinol	4.0	100	100	---	97	100	F
Princep	1.0						
B Surflan	4.0	100	100	---	100	100	---
Princep	1.0						
C Devrinol	4.0	63	100	Hw,L	80	96	Hw,L
Goal	2.0						
D Surflan	4.0	70	100	Hw,L	92	100	Hw
E Devrinol	2.0						
Princep	1.0	99	99	Hw	100	100	---
Goal	2.0						
F Surflan	2.0						
Princep	1.0	99	99	Hw	100	100	---
Goal	2.0						
G Goal	3.0	87	98	Hw	94	98	Hw
H Goal	2.0	98	100	Hw,L	99	100	---
Princep	1.0						
J Untreated	---	65	97	F,Fb,Hw,K,Pu,Sp	57	85	F,Fb,Hw,K,Pu

*Mist = low volume sprinkler that wets an area approximately 5' in diameter.

**Weeds Present: F = filaree; Fb = foxtail barley; Hw = horseweed; K = knotweed, L = flaxleaf fleabane; Pu = puncturevine, Sp = shepherd's purse.

TABLE 7 - THE PERFORMANCE OF HERBICIDES UNDER TWO TYPES OF LOW VOLUME EMITTERS IN DECIDUOUS ORCHARD

500, 425, 115, 110, 82-1

Location: Kearney Agricultural Center
Soil Type: Hanford sandy loam
Herbicides Applied: 3/4/82, 1/17/83, 1/25/84, 1/2/85
Type of Emitters: D = drip, M = mist

Varieties: Mission and Nonpareil
Plot Size: 8' x 68', Reps. 3
Trees Planted: 2/10/82, Spacing - 18' x 17'

		PERCENT WEED CONTROL, 6/22/85 AND 7/22/85							
		DRIP				MIST*			
		6/22/85		7/22/85		6/22/85		7/22/85	
		Percent	Weeds**	Injury Rating		Percent	Weeds**	Injury Rating	
Herbicide	lbai/A	Weed Control	Present	Mission	Nonpareil	Weed Control	Present	Mission	Nonpareil
A Devrinol Princep	4.0 1.0	55	C,Hw,L, Lo,Pu,S,Ss	0	0	81	C,Cu,Pu,Ss	1.7	0
B Surflan Princep	4.0 1.0	90	Cd,Hw,L,S	0	0	100	—	1.0	0
C Devrinol Goal	4.0 2.0	73	Hw,L,Pu,S,Ss	0.3	0	62	Hw,L	0.3	0
D Surflan	4.0	73	Hw,L	0.3	0	78	Hw,L,Ss	0	0
E Devrinol Princep Goal	2.0 1.0 2.0	88	C,Cu,Pu,S	1.0	0	100	—	2.7	0
F Surflan Princep Goal	2.0 1.0 2.0	92	Cu,Pu,S	1.0	0	100	—	2.7	0
G Goal	3.0	87	F,Hw,L,Pu,Ss	0	0	87	Hw,L	0	0
H Goal Princep	2.0 1.0	88	C,L,Pu,Ss	0.3	0	100	—	3.3	0
J Untreated	—	20	C,Cu,Hw,L,Pu,Ss	0	0	10	B,C,Cu,Hw,L, P,Pu,S,Ss	0	0

*Mist = low volume sprinkler that wets an area approximately 5' in diameter.

**Weeds Present: B = barnyardgrass; C = crabgrass; Cu = cupgrass; F = filaree; Hw = horseweed; L = flaxleaf fleabane; Lo = lovegrass; P = prickly lettuce; Pu = puncturevine; S = sowthistle; Ss = spotted spurge.

TABLE 8 - EVALUATION OF THREE HERBICIDES APPLIED THROUGH MICROSPRINKLERS SUPERIMPOSED ON VARIOUS COMBINATIONS OF HERBICIDES APPLIED DURING WINTER

Location: Kearney Agricultural Center
Soil Type: Hanford sandy loam
Varieties: Mission and Nonpareil
Herbicides Applied: 1/20/87*, 5/12/87**

Planted: 2/10/82, Spacing 7' x 18'
Plot Size: 9' x 68'
Evaluated: 7/3/87, 8/18/87

			PERCENT WEED CONTROL					
			Surflan** 4.0 lbai/A		Devrinol** 4.0 lbai/A		Endurance 4.0 lbai/A	
	Herbicides*	lbai/A	7/3/87	8/18/87	7/3/87	8/18/87	7/3/87	8/18/87
A	Devrinol	4.0	98	75	85	52	90	67
	Igran	1.0						
B	Surflan	4.0	100	92	100	87	100	82
	Igran	1.0						
C	Devrinol	4.0						
	Goal	1.0	95	77	80	50	100	85
	Igran	1.0						
D	Surflan	4.0						
	Goal	1.0	90	75	85	55	95	77
	Igran	1.0						
E	Devrinol	4.0						
	Princep	1.0	100	97	87	49	100	94
	Goal	2.0						
F	Surflan	4.0						
	Princep	1.0	100	99	100	90	100	99
	Goal	2.0						
G	Goal	2.0	96	77	100	92	100	99
	Princep	1.0						
H	Goal	2.0	90	74	90	70	85	65
	Igran	1.0						
J	Untreated	---	75	52	70	47	70	67

*Herbicides applied with conventional (boom) sprayer 1/20/87.
**Herbicides applied through microsprinklers, 5/12/87.

Weeds Present: Cudweed (Gnaphalium)
Spotted spurge (Euphorbia)
Horseweed (Erigeron)

TABLE 9 - EVALUATION OF THREE HERBICIDES APPLIED THROUGH MICROSPRINKLERS SUPERIMPOSED ON VARIOUS COMBINATIONS OF HERBICIDES APPLIED DURING WINTER

Location: Kearney Agricultural Center
Soil Type: Hanford sandy loam
Varieties: Mission and Nonpareil
Herbicides Applied: 1/20/87*, 5/12/87**

Planted: 2/10/82, Spacing 7' x 18'
Plot Size: 9' x 68'
Evaluated: 9/12/87

			PERCENT WEED CONTROL											
			Surflan** 4.0 lbai/A				Devrinol** 4.0 lbai/A				Endurance 4.0 lbai/A			
	Herbicides*	lbai/A	SS	H&F	Cd	Gr	SS	H&F	Cd	Gr	SS	H&F	Cd	Gr
A	Devrinol	4.0	70	55	62	100	0	100	100	100	45	70	100	100
	Igran	1.0												
B	Surflan	4.0	65	75	100	100	0	42	20	100	69	32	90	100
	Igran	1.0												
C	Devrinol	4.0												
	Goal	1.0	60	55	100	100	15	20	15	40	25	85	100	100
	Igran	1.0												
D	Surflan	4.0												
	Goal	1.0	50	80	100	100	15	40	50	100	80	75	80	100
	Igran	1.0												
E	Devrinol	4.0												
	Princep	1.0	65	100	100	100	32	87	30	20	57	100	100	100
	Goal	2.0												
F	Surflan	4.0												
	Princep	1.0	75	100	100	100	18	97	100	90	20	92	100	100
	Goal	2.0												
G	Goal	2.0	50	92	100	100	13	92	95	88	50	92	100	100
	Princep	1.0												
H	Goal	2.0	50	50	50	100	42	72	100	50	25	67	65	100
	Igran	1.0												
J	Untreated	---	50	52	35	70	10	42	0	10	40	50	50	25

*Herbicides applied with conventional (boom) sprayer 1/20/87.
**Herbicides applied through microsprinklers, 5/12/87.

Weeds Present: SS = spotted spurge (Euphorbia)
H&F = horseweed and flaxleaved fleabane (Erigeron)
Cd = cudweed (Gnaphalium)
Gr = grasses (Eriochloa and Digitaria)

TABLE 10 - EFFECTIVENESS OF HERBICIDES APPLIED THROUGH MICROSPRINKLERS

Location: Kearney Agricultural Center
Soil Type: Hanford sandy loam
Herbicides Applied: 1/7/88:
Surflan - 3.0 lbai/A)
Goal - 1/6 lbai/A)----- All plots treated with conventional sprayer
Princep - 1.0 lbai/A)
Herbicides injected into microsprinklers: 6/18/88

Trees Planted: 2/10/87
Varieties: Mission and Nonpareil
Evaluated: 8/16/88, 9/2/88

			PERCENT WEED CONTROL EVALUATIONS				
			8/16/88		9/2/88		
Herbicides*		lbai/A	Spotted Spurge	Other Broadleaves	Spotted Spurge	Other Broadleaves	Weeds Present
A	Surflan	2.0	22	75	17	87	Cd,Ff,Hw
B	Solicam	2.0	7	83	0	57	Cd,Ff,Hw
C	Surflan Ronstar	2.0 2.0	78	98	28	88	Ff,Hw
D	Ronstar	4.0	83	94	37	85	Cd,Hw
E	Endurance	2.0	90	93	80	92	Hw
F	Untreated	---	0	78	0	37	Cd,Ff,Hw

* The herbicides were mixed in 10 gallons of water and injected into the lines (after the filters) using a positive displacement pump (Ecodyne Meco-O-Matic). Each herbicide was injected during a period of 60 minutes. Following each herbicide, the sprinklers were run 30 minutes to clear the lines.

Weeds Present: Cd = cudweed
Ff = flaxleaf fleabane
Hw = horseweed (marestail)

TABLE 11 - EFFECTIVENESS OF SELECTED HERBICIDES INJECTED INTO MICROSPRINKLERS AND APPLIED WITH CONVENTIONAL SPRAYER

Soil Type: Hanford sandy loam
Trees Planted: 2/10/87
Herbicides Applied: 5/25/89

Almond Varieties: Mission and Nonpareil
Replications: Three
Evaluated: 8/1/89, 11/14/89

		PERCENT WEED CONTROL				
		8/1/89		11/14/89		
Herbicide	lbai/A	Weed Control	Weeds Present	Spotted Spotted	Cudweed	Other Broadleaves
Injected into irrigation water*						
A Endurance	2.0	94	Ss	95	62	10
B Endurance	4.0	99	Ss	96	82	43
C Goal	1.6	95	Cd,Ss	75	82	58
D Ronstar	3.0	96	Cd,Hw,Ss	47	60	15
E Untreated	---	38	Cd,Hw,Ss	30	35	0
Applied with CO_2 sprayer						
F Endurance	4.0	99	Ss	91	88	71
G Ronstar	4.0	99	Ss	94	94	85
H Goal	1.6	99	Ss	73	75	46

* The herbicides were mixed in 10 gallons of water and injected (beyond the filters) using a positive displacement pump. Each herbicide was injected during a period of 60 minutes. Following each herbicide injection, the sprinklers were run 30 minutes to clear the main line before the injection of another herbicide.

** Weeds Present: Cd = cudweed; Hw = horseweed (marestail); Ss = spotted spurge.

For Additional Reading

1. Clothier, B., Scotter, D., and Harper, E., 1985. Three Dimensional Infiltration and Trickle Irrigation Transactions of the ASAE, Vol. 28, No.2, pp. 497-50l.

2. Pillsbury, A., 1968. Special Agricultural Uses of Sprinkler Irrigation, F.A.O. Agricultural Development Paper, No. 88, Rome.

3. Clothier, B.E., 1984. Solute Travel Times During Trickle Irrigation Water Resources, Vol. 20, No. 12, pp. 1848-52.

4. Lange, A., Aljibury, F., Fischer, B., Humphrey, H. and Otto, H., 1974. Weed Control Under Drip Irrigation in Orchard and Vineyard Crops, Proceedings of the Second International Drip/Trickle Irrigation Congress, San Diego, pp. 422-24.

5. Hall, Bernarr, 1985. History of Drip/Trickle Irrigation, Proceedings of the Third International Drip/Trickle Irrigation Congress, Fresno, CA, Vol. II, pp. 1-7.

6. Biscomer, Inge, 1985. CHEMIGATION: A Practical Overview, Proceedings of the Third International Drip/Trickle Irrigation Congress, Fresno, CA, Vol. II, pp. 477-84.

7. Fereres, E., Technical Editor, 1981. Drip Irrigation Management Leaflet #21259, Div. of Agr. Sci., University of California, 39 pages.

8. Clothier, B., 1985. Fundamentals of Fertigation, Seminar Proceedings, the New Zealand Horticultural Trade Fair, pp. 38-44.

9. Fischer, B., Goldhamer, D., Babb, T. and Kjelgren R., 1985. Preemergence Herbicide Performance Under Drip and Low Volume Sprinkler Irrigation, Proceedings of the Third International Drip/Trickle Irrigation Congress, Fresno, CA, Vol. 11, pp. 486-90.

10. Lange, A.H., Kempen, H., Fischer, B., Elmore, C., 1980. Weed Control in Almond Orchards, Leaflet 21069, University of California DANR.

11. Meith, C., Connell, J., 1985. Nontillage and Strip Weed Control in Almonds, Leaflet 2770. University of California DANR.

12. Micke, W.C., Moulton, S.D., 1982. Commercial Almond Production in California: Information For Prospective Growers. Leaflet 2824, University of California DANR.

13. Elmore, C.L., 1989. Vegetation Management Systems in Almond Orchards, California Agriculture, Vol. 43, No. 4.

14. Elmore, C.L., Asai, W.K., Hendricks, L.C., Elkins, R.B., 1989. Plant Composition of Orchard Floors, California Agriculture, Vol. 43, No. 4.

15. Klonsky, K., Elmore, C.L. Almond Orchard Floor Management Costs, California Agriculture, Vol. 43, No. 4.

16. Prichard, T.L., Elmore, C.L., 1989. Orchard Water Use and Soil Characteristics, California Agriculture, Vol. 43, No. 4.

17. IPM Manual Group, Ohlendor, B.P., Senior Writer, 1988. Integrated Pest Management For Almonds, Publication 3308, University of California, Division of Agricultural and Natural Resources.

18. Finch, C.U., Sharp, C.W., 1976. Cover Crops in California Orchards and Vineyards. Soil Conservation Service, USDA.