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Shot hole lesions on fruit first appear as small spots. On leaves, small, dark fruiting structures (sporodochia) in the center of the lesions are characteristic of the disease.

Effect of fungicides on shot hole disease of almonds

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Several registered fungicides evaluated over a 7-year period in the southern San Joaquin Valley controlled the disease on fruit. Captan, captafol, and ziram preceded by dormant copper provided the most consistent control. Fungicides protected against yield losses in a heavy-disease year but had no effect on yields when the disease was not prevalent.

Almond trees are subject to several flower, fruit, and foliage diseases. Of these, brown rot, shot hole, and jacket rot are most common and occur during or shortly after bloom. Brown rot (*Monilinia laxa*) causes death of flowers and twigs, jacket rot (*Botrytis cinerea*) destroys young fruit, and shot hole (*Stigmina carpophila*) causes defoliation. These diseases are controlled by one to three applications of fungicides during bloom, with additional treatments after bloom for shot hole when necessary.

All three diseases are favored by rainfall. Growers regularly use control measures in northern and central California orchards, where rainfall during bloom is expected in most years. Since high rainfall conducive to serious disease outbreaks is less common in the southern San Joaquin Valley, many southern orchards have not been regularly treated for control of bloom diseases.

In the southern San Joaquin Valley, brown rot and jacket rot sporadically cause considerable damage, while shot hole disease occurs more frequently. Irrigation by high-angle sprinklers that direct water into the tree canopy creates a suitable environment for shot hole, and heavy infection is often found in the lower canopies of such trees.

Some almond growers apply copper fungicide during dormancy to aid in control of several diseases, including shot hole, brown rot, and bacterial canker. However, data supporting this practice for control of these diseases have not been available.

We conducted almond orchard studies to: (1) test the effectiveness of several fungicides for control of shot hole; (2) determine the benefit of a dormant application of cupric hydroxide followed by applications of ziram during bloom for control of shot hole; and (3) evaluate the effect of fungicide treatments on almond yield.

Almond orchard study

Tests of fungicide effectiveness were conducted in two commercial almond orchards in Kern County, California. We used one orchard with the Thompson cultivar in 1981 and 1982, and the other with cultivar Merced in 1983 through 1986. Trees in both orchards were 9 years old in the first experimental year. Before these experiments, the Thompson orchard had received no disease control and the Merced orchard had received one ziram application annually at the popcorn stage. The Thompson orchard was sprinkler-irrigated for 12 hours at 7-day intervals and the Merced orchard for 24 hours at 13-day intervals. Water reached into the lower third of the tree canopy in both orchards.

Fungicides tested were: cupric hydroxide 53W (Kocide 101), captafol 80 DWG (Difolatan), captan 50W (Orthocide), iprodione 50W (Rovral), maneb 80W (Dithane M22), and ziram (Ziram 76W). Materials were applied with a concentrate airblast sprayer traveling at 2 miles per hour and delivering 80 to 100 gallons per acre at 150 pounds per square inch.

The effect of dormant copper fungicide application on control of shot hole in spring was tested with: (1) cupric hydroxide applied in late January followed by ziram applications in spring (copper-then-ziram), and (2) ziram applications in spring (ziram-only).

Application dates, determined by plant growth stage, were approximately 2 weeks apart. The dormant treatment was in late January before any new flower or leaf tissue appeared. Spring applications were made when petals emerged from bud scales but flowers were not open (PB), at full bloom to early petal fall (PF), and 2 weeks after petal fall when small fruit were present (APF). Spring treatments were applied twice (at PB and PF) or three times (at PB, PF, and APF). Five five-tree plots were arranged in a randomized complete block design. A different location in the orchard was used each year.

Shot hole incidence in the center three trees of each plot was evaluated on fruit each year and on leaves in 1986. We counted the lesions on each of 25 to 100 fruit selected randomly from the lower portion of each tree (75 to 300 fruit per plot). In 1986, lesions were counted on four fully expanded leaves on 25 shoots of each tree (300 leaves per plot). *Stigmina carpophila* was recovered from cultures of representative fruit lesions and sporodochia, the fruiting structures of the shot hole fungus, were present in leaf lesions. We collected data in May 1981, 1982, 1983, and 1987 and late March 1986. We did not collect data in the spring of 1984 and 1985 because shot hole lesions were scarce.

Yield measurements were taken from treatments in the 1986 fungicide-effectiveness experiment.

In 1987, fungicide tests similar to those just described were established in Kern, Fresno, and Tulare County orchards with the cultivar Merced. The Kern County orchard was sprinkler-irrigated, and the Fresno and Tulare County orchards furrow-irrigated. The Tulare County orchard had not been treated previously for disease control; the other two had been treated annually for

TABLE 1. Efficacy of several fungicides for control of shot hole on almond

	Average number of lesions◊									
	Per fruit								Per leaf	
	Two applications§			Three applications§					Two appl.§	Three appl.§
Fungicide and rate*	1981 Kern	1983 Kern	1986¶ Kern	1982 Kern	1986¶ Kern	1987 Kern	1987 Fresno	1987 Tulare	1986¶ Kern	1986¶ Kern
Cupric hydroxide 53W, 8 lb (Dor)** THEN Ziram 76W, 8 lb	2.3 a	1.3 ab	0.9 a	0.2 a	0.2 a	0.01 a	.002 a	.022 a	0.20 ab	0.13 a
Captafol 80 DWG, 6 lb	—	0.5 a	0.2 a	—	0.3 a	—	—	—	0.41 bcde	0.45 cde
Captan 50W, 10 lb	3.2 ab	2.1 abc	0.6 a	0.2 a	0.6 a	0.03 a	.002 a	.015 a	0.35 abcd	0.48 de
Iprodione 50W, 1 lb	—	3.6 c	3.9 c	—	0.4 a	0.66 ab	.001 a	.060 a	0.25 abcd	0.15 a
Maneb 80W, 8 lb	3.2 ab	3.0 bc	4.0 c	0.5 a	0.8 a	0.11 a	.003 a	.064 a	0.40 bcde	0.28 abcd
Ziram 76W, 8 lb	4.5 b	9.4 d	11.7 d	1.0 a	2.1 b	0.05 a	.017 ab	.029 a	0.60 e	0.24 abc
Cupric hydroxide 53W, 8 lb (Dor)**	7.3 c	12.4 e	—	2.6 b	—	1.11 b	.002 a	.239 b	—	—
Untreated	8.6 c	14.0 e	13.4 e	3.2 b	13.4 e	3.41 c	.019 b	.252 b	1.20 f	1.20 f
P = 0.05, LSD =	1.6	1.8	0.9	2.0	0.9	0.81	.017	.080	0.20	0.20

* Rate = pounds per acre as formulated. Materials applied by air-carrier sprayer, 80-100 gpa, 2 mph, 150 psi.
◊ Five replications (eight replications Fresno, Kern 1987) of five-tree plots 75-300 fruit or 300 leaves collected from center three trees of each plot. Treatments followed by the same letter do not differ significantly, P = 0.05, ANOVA and DMRT.
§ Applications made 2 weeks apart beginning when petals showed but flowers were not open.
¶ Two- and three-application treatments part of same experiment, Kern 1986.
** Dor = dormant application, applied once late January at budswell.

brown rot and shot hole. Five (Kern County) and eight (Fresno and Tulare counties) replications of five-tree plots were arranged in a randomized complete block design. Shot hole incidence on fruit was evaluated as previously described. All fruit from the center three trees of each plot were harvested and weights adjusted for dry kernel weight.

We received Kern County rain data in 1981 and 1982 from the National Weather Service approximately 10 miles from the test site and in 1983-87 from the orchard owner a mile from the experiments. California Irrigation Management Information System (CIMIS) stations were sources in Fresno and Tulare counties in 1986 and 1987.

Rainfall during February and March in Kern County was 2.93, 0.67, 6.22, 1.08, 2.50, and 4.11 inches in the 6 years, 1981 through 1986, respectively. In the same period in 1987, rainfall was 2.68, 4.03, and 3.81 inches in Kern, Fresno, and Tulare counties, respectively.

Fungicide effectiveness. On fruit, captafol (not registered for use on almonds), captan, iprodione, maneb, and copper-then-ziram were significantly better than the untreated check for control of fruit lesions in all years (table 1). Ziram-only was significantly better than the check in every test except Fresno, 1987.

Captafol was consistently among the best treatments. Copper-then-ziram, captan, and maneb performed similarly in every test except one in 1986, where two applications of copper-then-ziram or captan were significantly better than two of maneb.

Control by ziram-only was equivalent to that of captan and maneb, except in 1983 and 1986, both years of severe shot hole infection. In those years and in 1981, copper-then-ziram was significantly better than ziram-only. Dormant copper application did not significantly improve control by ziram in the low-disease-incidence years of 1982 and 1987.

Iprodione was less effective than the best treatments where two applications were made, but there were no significant differences among three applications of iprodione, copper-then-ziram, captafol, captan, or maneb. Direct comparison of two versus three applications can be made only with data from 1986, when both timings occurred in the same experiment. In that year, three applications of iprodione, maneb, or ziram-only were better than two, but two or three applications of the other materials provided similar control.

On leaves, all treatments in 1986 were significantly better than the untreated check. Dormant copper significantly improved control where two but not where three applications of ziram were made, and three applications of ziram-only were better than two. Differences among other treatments cannot be determined, because results of statistical analysis were unclear.

Effect of fungicides on yield. There were no significant differences in 1986 among the highest yielding treatments: captafol, captan, iprodione, and maneb (table 2). All were significantly better than copper-then-ziram, ziram-only, and the untreated check. Copper-then-ziram was significantly better than ziram-only, and both were significantly better than the check.

No significant differences in yields were found among any treatments and the untreated check in the Kern, Fresno, or Tulare County orchards in 1987. Shot hole was present at very low levels. Brown rot and jacket rot were not observed at any of the test sites.

Discussion

In general, captafol, captan and copper-then-ziram were most consistent in reducing shot hole infections on fruit. When dis-

TABLE 2. Effect of fungicides on yield of almond trees, cultivar Merced

	Average pounds nutmeats per tree◊			
Fungicide, rate*	1986 Kern	1987 Kern	1987 Fresno	1987 Tulare
Captafol 80 DWG, 6 lb	21.6 ab	—	—	—
Captan 50W, 10 lb	23.2 ab	38.7 a	30.4 a	9.2 a
Iprodione 50W, 1 lb	23.7 a	36.8 a	37.8 a	9.3 a
Maneb 80W, 8 lb	23.2 ab	32.5 a	30.2 a	11.3 a
Ziram 76W, 8 lb	13.8 c	38.0 a	37.2 a	10.9 a
Cupric hydroxide 53W, 8 lb (Dor)§ THEN Ziram 76W, 8 lb	19.2 b	41.7 a	33.5 a	10.7 a
Cupric hydroxide 53W, 8 lb (Dor)§	—	32.5 a	31.3 a	9.5 a
Untreated	7.0 d	33.0 a	32.4 a	10.5 a
P = 0.05, LSD =	4.3	11.2	7.7	2.5

NOTE: Five replications at Kern County 1986, 1987, eight replications at Fresno and Tulare counties, 1987. Five-tree plots, center three trees of each plot harvested.
* Rates are pounds per acre, as formulated. Materials applied by air-carrier sprayer, 80-100 gpa, 150 psi. Three applications at 2-week intervals, beginning at early bloom.
◊ Treatments followed by the same letter do not differ significantly, P = 0.05, ANOVA and DMRT.
§ Dor = dormant application, applied once late January at budswell.

ease incidence was low (1982 and 1987), the choice of fungicide had little effect on control. Even in years with low disease incidence, however, shot hole was more prevalent in untreated than in treated trees. We did not obtain sufficient data to evaluate control of leaf infections. The relative importance of fruit and leaf infections and the manner in which shot hole damages trees are not clearly understood. Shot hole is known to cause defoliation, but the extent to which fruit are damaged directly is uncertain.

A dormant application of copper fungicide improved control of shot hole by ziram when disease incidence was high. Recent evidence suggests that spores of the shot hole fungus in buds and on tree surfaces may be an important source of overwintering inoculum on almond, and the amount of this inoculum may influence disease incidence in the spring. Dormant application of copper fungicide in our studies may have reduced or impaired overwintering inoculum, improving control by ziram applications in the spring.

With regard to fungicide effects on yield, conditions in 1986 and 1987 may represent two extremes, the former producing severe and the latter no measurable loss in yield to diseases. Less obvious losses may occur in years of intermediate disease levels.

The reductions in yield reported here cannot be attributed entirely to shot hole. Several diseases were enhanced by the high rainfall during bloom in 1986. In addition to shot hole, there were symptoms of brown rot and jacket rot in the test area, but we do not have data on the incidence or severity of either. Other unrecognized disease organisms also may have been active and contributed to reduced yield. Treatments with the broad-spectrum fungicides captafol, captan, iprodione, and maneb resulted in higher yields than those with ziram, a narrow-range fungicide, suggesting that several disease organisms, not just the shot hole fungus, contributed to yield loss. Fungicides active against a variety of organisms should be included in programs for bloom disease control of almond.

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Foraging in Central Valley agricultural drainage areas

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For as long as there have been humans in the Central Valley grasslands, they have hunted, fished, and gathered plant or animal life for consumption. "Foraging" became a health concern with the evidence of selenium accumulation at Kesterson Reservoir. A survey suggests that a large number and variety of people forage. The amounts and frequency of consumption are probably not great enough to be a health hazard to any one person or group, but there is still some cause for concern.

The discovery in 1983 of deaths and deformities among migratory waterfowl at the Kesterson Reservoir in the central San Joaquin Valley focused national attention on drainage and drainage-related problems in California. These problems have affected agricultural productivity and water quality but, in the context of fishing and hunting, it is their overlapping effects on fish and wildlife and public health that are of concern.

In the fall of 1986, the San Joaquin Valley Drainage Program, an interagency effort to resolve the selenium issue, requested our assistance in assessing the nature and extent of natural resource use by people in the Central Valley. Between January and May 1987, we conducted a study in the drainage area of the central San Joaquin Valley, a region stretching from Gustine to Mendota between the San Joaquin River and interstate highway I-5.

In mid-1987, the California Department of Health Services completed a report on the public health implications of elevated selenium levels in this area. No adverse effects on local residents were found, but levels of selenium in fish, aquatic birds, and waterfowl were unsafe for unrestricted human consumption. As a precaution, public warnings were issued advising people to avoid or limit consumption of fish and waterfowl taken in the Kesterson Reservoir and Grasslands.

Because selenium concentrations persist in the soil and sediment, the Department of Health Services recommended further studies to assess potential health risks. Our study was a preliminary effort to identify high-risk groups of people who collected plants and animals in the drainage area. These activities included hunting, fishing, trapping, clamming, frogging, and the collection of crayfish and edible plants. We gave legal and illegal activities equal weight under the term "foraging" to include all use of flora and fauna for consumption. Those who practiced these activities were termed "foragers."

Study design

Assuming a journalistic stance in our research, we sought to contact individuals who were foragers themselves or who could provide detailed accounts of such activities. This information was constricted by: (1) the social system, which produced some hesitancy among informants to disclose hunting and fishing sites; and (2) the legal system, which produced a reticence to discuss any illegal practices.

The timing of our study also made direct observation of the full fishing and hunting season impossible. We relied instead on secondary sources for the bulk of our information. These included representatives from water districts (canal tenders), the California Department of Fish and Game, California Department of Parks and Recreation, Merced County Public Health Office, California State Police, U.S. Fish and Wild-