OIL SPRAY FOR WEED CONTROL IN NONCULTIVATED CITRUS ORCHARDS

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Several thousand acres of citrus orchards in California are now being operated without disturbance of the soil by tillage. Two methods are in use. In one, a permanent covercrop is maintained. In the other, weed growth is eliminated; the soil remains more or less bare at all times. Usually, in orchards under this latter system, the weeds are destroyed by an oil spray, sometimes supplemented with hand-hoeing. In certain orchards, however, the weeds are eliminated by hand-hoeing, without the use of oil.

Survey Methods Used

The oil-spray method has aroused widespread interest. At the request of a committee of growers, a preliminary study has been made by the Agricultural Extension Service of the University of California. Presented herewith are such records as growers had readily available, together with observations made during the survey. This is not a report on experimental research, but a compilation of grower costs, experience, and opinion.

Growers were interviewed in San Bernardino, Orange, Los Angeles, and Ventura counties. Of these, 10 in San Bernardino, 8 in Orange, and 1 in Ventura County (with a total of 800 acres), had complete enough data to be included in the tabular summary. Many of those interviewed had incomplete records, which are therefore not tabulated. Each record is given a number. Table 1 presents general information on each orchard in the study. Table 2 shows the hours of man labor, the field power, the spray rig, the gallons of oil used, and the cost per acre by years.

During the first two or three years, the oil-spray method usually costs more than conventional tillage. Fairly large quantities of oil are required during this period, and somewhat smaller quantities thereafter.

Types of Spray Rigs

Several types of spray rigs are used for spraying weeds (see figs. 1 to 6, page 2). A few growers have conventional rigs of the pest-control type. Others construct or purchase

smaller rigs, which may be mounted on trucks, trailers, or horse-drawn chassis. Air-cooled gasoline motors of 1½ or 2 horsepower are used to drive small piston-type or gear pumps. One grower uses the hydraulic-lift gear pump driven from the power take-off of his tractor. The spray nozzles on these rigs are of the Hudson type, with a no. 2 to no. 4 disk. Such equipment, with two hose, can spray about 1 acre per hour (or less if the weeds are tall and numerous).

Several growers have constructed rigs with booms that spray the entire middle while being pulled between the tree rows. Wide-angle spray nozzles, spaced at intervals, give complete coverage when the horizontal boom is 12 to 15 inches above the ground. Nozzles that throw a fan-shaped spray have proved satisfactory on booms. Supplemental spraying with hose and hand nozzles may be required once or twice a year on areas not reached by the boom. About 3 acres per hour can be sprayed with such equipment. One man can work the boom rigs. Three men (a driver and two spray operators) are required for outfits of the conventional type. If the equipment is horse-drawn, only the two spray men are needed. After the weed population is reduced to a point where spot spraying becomes practical, the use of hose and hand-nozzle equipment will be sufficient.

Pressures used range from 75 to 250 pounds per square inch; most growers prefer 75 to 100 pounds. High pressures cause excessive fogging and have sometimes given poorer coverage.

Management Practices

The best season to place an orchard under this system of soil management is late spring or summer. Weeds are disked under in the usual way, and any irregularities in the grade are leveled. Broad, shallow irrigation furrows have proved most practical because they reduce to a minimum the clogging of the furrows by leaves. They also give better water distribution, are more easily maintained, and permit easier handling of wheeled equipment in the orchard.

When weeds are 2 to 4 inches high they are sprayed with orchard-heater oil of 28 to 32 specific gravity. Some growers have used Diesel oil when heater oil was not available. The lower grades of oil are most effective and least expensive. The oil is applied sparingly, the object being to wet the weeds without runoff to the soil. Perennials, such as Bermuda grass, Johnson grass, and morning-glory, are eliminated by repeated

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Fig. 1.--Boom spray rig, trailer type.

Fig. 2.--Boom spray rig operated by one man.

Fig. 3.--Horse-drawn spray rig with boom spray and hose attachment.

Fig. 4.--Horse-drawn spray rig with two hose and hand-nozzle attachments.

Fig. 5.--Rear view of the rig shown in figure 4.

Fig. 6.--Hand nozzle on hose attachment.

spraying at short intervals. Morning-glory in particular should be sprayed as soon as fairly large leaves appear. Weeds should not be allowed to grow more than 4 inches between sprayings, nor to go to seed.

During the first two or three years, while the weed population is large, power sprayers are used. After this period most of the weeds are gone, and in most orchards the few remaining patches can be controlled with a knapsack sprayer or a hoe.

Undiluted oil appears to give the most economical weed control and may be used in simple rigs having no agitator. Some growers have used a 50-50 mixture of oil and water; but experience has shown that no economies result from this practice.

San Bernardino County Records

The ten orchards included in the San Bernardino County records covered 183.7 acres and ranged in size from 6.5 to 55 acres. Table 1 presents general information on each orchard in order to help visualize the problems encountered in applying oil. Each record is given a number, which is the same in table 2. Soil type varied from Hanford gravelly, sandy loam to Placentia loam. All orchards were thirty years old or over, except no. 9, a six-year-old grapefruit grove. Trees (90 to 108 per acre) were spaced 20 × 20 to 22 × 22 feet. Being unusually large, they shaded a considerable portion of the land area. The furrow method of irrigation was used in all groves. Weed infestation was reported heavy at the beginning of the oil-spray program.

TABLE 1
General Information on the Orchards Included in the 1943 Study; San Bernardino and Orange Counties

Orchard no.	Acres	Soil type	Slope	Type of fruit	Age of trees, in years	Planting distance, in feet	Weed infestation	Predominant weeds
San Bernardino County (total acres, 183.7)								
1	9.7	Hanford sand, Hanford loam	1%	Valencia	30	22 × 22	Very heavy	Morning-glory, Bermuda, Johnson grass
2	55.0	Hanford sand, Placentia loam	1 to 3%	Valencia, navel, grapefruit	30-50	22 × 22	Very heavy	Morning glory, Bermuda, Johnson grass, chickweed
3	10.0	Hanford loam	2%	Lemon	52	21 × 21	Very heavy	Morning-glory, Bermuda, malva, pigweed
4	9.5	Hanford coarse, sandy loam	1½%	Valencia, navel	35	20 × 22	Heavy	Bermuda, Johnson grass, puncture vine
5	7.0	Hanford sand	1½%	Valencia, navel	40	20 × 20	Very heavy	Bermuda, Johnson grass, puncture vine
6	14.0	Hanford sand	1-3/4%	Valencia	40	20 × 20	Very heavy	Bermuda, Johnson grass, puncture vine
7	20.0	Hanford coarse, sandy loam	1½%	Navel	40	20 × 20	Very heavy	Bermuda, Johnson grass, puncture vine
8	42.0	Hanford sand	½ to 1%	Navel	50	22 × 20	Heavy	Chickweed, malva, pigweed
9	6.5	Hanford loam	1½%	Grapefruit	6	22 × 20	Very heavy	Morning-glory, nut grass, puncture vine
10	10.0	Hanford gravelly, sandy loam	10% (2% furrow)	Navel	40	22 × 22	Fairly heavy	Bermuda, malva, pigweed, purslane
Orange County (total acres, 196)								
1	100.0	Sandy loam	Less than 1%	Valencia	14	21 × 21	Very heavy	Morning-glory, Bermuda, Johnson grass, malva
2	20.0	Sandy loam	Less than 1%	Valencia	18-29	25 × 25	Very heavy	Morning-glory, Bermuda, Johnson grass, malva
3	10.0	Sandy loam	Less than 1%	Valencia	30	25 × 25	Very heavy	Morning-glory, Bermuda, Johnson grass, malva
4	10.0	Clay	Less than 1%	Valencia	20	24 × 24	Very heavy	Morning-glory, Bermuda, malva, thistle
5	4.5	Sandy loam	Less than 1%	Valencia	33	24 × 25	Very heavy	Morning-glory, Bermuda, malva, bunch grass
6	31.0	Clay loam	1%	Valencia	26	22 × 22	Very heavy	Morning-glory, Bermuda, malva, oxalis
7	10.0	Sandy loam	Less than 1%	Valencia	30	24 × 24	Very heavy	Malva, puncture vine, pigweed
8	10.5	Medium	Less than 1%	Valencia	30	24 × 24	Very heavy	Morning-glory, Bermuda, pigweed, bunch grass

TABLE 2

Oil-Spray Weed Control in Citrus: Inputs and Costs per Acre, San Bernardino, Orange, and Ventura Counties

Orchard number and years the spray work was done	Number of applications and kind of field power used	Labor and materials used per acre					Cost per acre, in dollars			
		Hours man labor	Hours horse rig	Hours truck rig	Gallons oil per application	Gallons oil, total	Man labor	Field power and rig	Oil	Total
San Bernardino County										
No. 1										
1940	8, horse	26.5	15.0	...	48	379	13.13	15.00	15.16	43.29
1941	4, horse; 4, hand	16.0	10.3	...	42	338	8.00	10.24	13.52	31.76
1942	4, horse	7.3	5.0	...	36	143	3.63	5.00	5.72	14.35
1943	3, horse; 1, hand	3.8	1.8	...	36	83	2.85	1.70	3.32	7.87
No. 2										
1940	Hardy spray	29.1	14.5	...	...	182	10.18	3.63	5.45	19.26
1941	Rig, 1.5 hp.	16.6	14.8	...	...	195	6.81	3.70	5.85	16.36
1942	Rig, 1.5 hp.	12.2	10.0	...	...	135	5.84	2.51	4.44	12.79
1943	Rig, 1.5 hp.	12.2	7.4	...	...	100	8.40	1.85	3.49	13.74
No. 3										
1941	2, truck	9.6	...	3.2	115	230	6.72	1.60	8.28	16.60
1942	1, truck; 2, horse	11.2	5.6	1.6	57	170	7.84	1.32	6.12	15.28
1943	1, truck; 1, horse	8.8	2.0	1.6	75	150	6.16	1.40	6.37	13.93
No. 4										
1942	4, truck	9.1	...	4.5	61	242	6.08	4.50	8.48	19.06
1943	4, truck	9.8	...	4.9	75	302	9.82	4.90	10.11	24.83
No. 5										
1942	5, horse	10.0	5.0	...	55	276	7.50	5.00	11.06	23.56
1943	5, horse	8.1	4.0	...	46	226	6.10	4.00	9.06	19.16
No. 6										
1942	5, horse	11.8	5.9	...	68	339	8.84	8.92	13.55	31.31
1943	5, horse	7.3	3.6	...	41	203	5.46	5.47	8.10	19.03
No. 7										
1942	6, horse	10.0	5.1	...	49	296	7.50	5.01	11.83	24.34
1943	5, horse	4.4	2.2	...	23	115	3.32	2.21	4.60	10.13
No. 8										
1942	4, tractor	4.4	...	1.9*	40	160	3.52	2.84	5.42	11.78
1943	2, tractor; 1, horse	2.1	0.1	1.0*	42	125	1.67	1.72	4.69	8.08
No. 9										
1942	2, horse	5.7	2.8	...	89	177	4.27	2.79	6.19	13.25
1943	3, truck	12.5	...	4.7	145	435	10.03	4.68	16.54	31.25
No. 10										
1943	4, tractor	1.2	...	1.2*	45	180	1.20	1.40	7.65	10.25
Orange County										
No. 1										
1941	4, truck, hose	27.9	...	9.3	118	471	11.16	4.65	18.83	34.14
1942	4, truck, boom, hose	10.8	...	3.6	54	217	4.84	1.80	8.69	15.33
1943	4, truck, boom, hose	7.7	...	2.6	52	207	5.76	1.28	9.30	16.34
No. 2										
1941	4, truck, hose	22.2	...	7.4	89	357	8.88	3.70	11.10	23.68
1942	4, truck, boom, hose	11.4	...	3.8	54	215	5.08	1.90	5.70	12.68
1943	4, truck, boom, hose	12.2	...	4.0	69	277	9.11	2.03	6.08	17.22
No. 3										
1941	4, truck, boom, hose	24.7	...	8.2	99	395	9.90	4.13	15.80	29.83
1942	4, truck, boom, hose	16.6	...	5.5	79	317	7.49	2.77	12.68	22.88
1943	4, truck, boom, hose	8.8	...	2.9	53	212	6.54	1.46	9.54	17.54

*Tractor hours - not computed in the average.

TABLE 2 (Continued)

Orchard number and years the spray work was done	Number of applications and kind of field power used	Labor and materials used per acre					Cost per acre, in dollars			
		Hours man labor	Hours horse rig	Hours truck rig	Gallons oil per application	Gallons oil, total	Man labor	Field power and rig	Oil	Total
Orange County (Continued)										
No. 4										
1941	4, truck	5.3	...	2.6	51	203	3.98	4.52	8.30	16.80
1942	6, truck	7.9	...	4.0	27	159	5.93	4.00	6.36	16.29
No. 5										
1942	2, truck; 3, hand	36.0	...	3.1	51	255	25.20	2.33	19.39	46.92
1943	4, truck	14.5	...	7.1	55	221	14.20	5.53	9.95	29.68
No. 6										
1942	3, truck	8.7	...	8.7	189	500	6.97	2.18	15.75	24.90
1943	4, truck	12.9	...	6.4	100	400	8.80	4.84	14.00	27.64
No. 7										
1941	2, truck	11.6	...	11.6	110	220	7.54	2.90	6.60	17.04
1942	3, truck, spot	11.8	...	10.8	67	200	8.26	2.70	7.00	17.96
1943	2, truck, spot	6.6	...	4.6	50	100	4.62	1.15	4.50	10.27
No. 8										
1942	2, truck, spot	4.5	...	2.5	75	149	4.67	0.50	6.21	11.38
1943	4, truck, spot	12.1	...	5.9	73	289	13.89	1.18	16.88	31.95
Averages for San Bernardino, Orange, and Ventura counties										
San Bernardino County:										
First year, 10 records, 183.7 acres		11.7	8.0	3.8	63	246	6.89	5.07	9.31	21.27
Second year, 9 records, 173.7 acres		9.8	5.8	3.7	59	234	6.56	4.25	8.73	19.54
Third year, 3 records, 74.7 acres		9.4	5.7	1.6	55	143	5.21	2.97	5.51	13.69
Fourth year, 2 records, 64.7 acres		8.0	4.6	...	36	91	5.62	1.78	3.40	10.80
Orange County:										
First year, 85 records, 196.0 acres		17.6	...	6.7	98	319	9.79	3.11	12.75	25.59
Second year, 85 records, 196.0 acres		12.2	...	5.9	64	252	8.56	3.10	9.85	21.80
Third year, 41 records, 140.0 acres		8.8	...	3.5	56	199	6.51	1.48	7.36	15.34
Ventura County:										
Second year, 17 blocks, 267.0 acres		34.9	18.2	...	59	730	22.70	3.65	29.20	55.55
Third year, 8 blocks, 103.1 acres		28.4	14.6	...	80	580	18.49	2.93	23.21	44.63
Fourth year, 4 blocks, 50.2 acres		25.0	13.1	...	77	484	16.38	2.62	19.37	38.37

The grade of the furrows was between 1 and 2 per cent, with cross slopes up to 23 per cent.

For each of the records, table 2 shows the hours of labor, the field power, the gallons of oil per acre, the number of applications per year, and the annual costs per acre. At the bottom of the table is shown the average for each of these items by years.

This table reveals a wide range in inputs of labor, oil, and costs--a variation largely explained by the difference in weed growth, in type of equipment used, and in timeliness of operations. The first year is the heavy cost year, which varied from \$10.25 to \$43.29, the average for all records being \$21.77. Conventional cultivation, including furrowing out and hoeing, will cost \$10.00 to \$30.00 per acre. Gallons of oil applied the first year ranged from 160 to 379, with an average of 246 per acre. The average per application was 63 gallons. The wide range in man-hours is due largely to the type of

equipment used. Whereas no. 10 needed only 1.2 man-hours per acre, no. 2 needed 29.1 for the first year's operations.

The average total cost for the second year was \$19.54 per acre (234 gallons of oil); the third year \$13.69 (143 gallons of oil); and the fourth year \$10.80 (91 gallons of oil).

Growers believe that the improvement of spray rigs, together with better management and timing of operations, can considerably reduce the hours of labor and the quantity of oil necessary.

Certain individual orchards in this county require special comment:

Orchard no. 1 began using oil spray July 1, 1940. The orchard was heavily infested with morning-glory, Bermuda grass, Johnson grass, puncture vine, and the usual run of annuals. The winter and spring growth of weeds was thoroughly disked, and permanent broad furrows were laid out for irrigation. No cultivating of any kind has been done since that date. A 3-horsepower

spray rig was set up on an old Ford chassis equipped with shafts and pulled by one horse. Two hose extensions were attached, with Hudson garden-type spray nozzles. The first year, the orchard was sprayed eight times, the treatment requiring a total of 26.5 man-hours of labor, 15 hours of horse and rig, and 379 gallons of orchard-heater oil per acre, at a total cost of \$43.29. The second year there were four sprayings with the power rig, and some particularly bad spots received extra treatments with a hand spray. Total costs for that year were \$31.76 per acre. The third year, costs were cut to \$14.35 per acre; and the fourth year (1943) to \$7.87. The owner considers that he now has the weed problem under control and that future work will be merely a matter of preventing the few remaining weeds from seeding. Gratified with the results obtained, he would be unwilling to resume his old cultural practices.

No. 2, a 55-acre grove, has been under this method for four years. The tabulated figures for this record show similar results. The first year's cost was \$19.26 per acre; the fourth year's, \$13.74. The owner is much pleased.

No. 3 has been using this method for three years, with more than satisfactory results.

No. 9 is a six-year-old grapefruit grove on Hanford loam soil, with weed growth heavy when the orchard was placed under noncultivation.

No. 10, started in 1943, has low costs because the grower has developed an efficient rig with boom sprays. This outfit, operated by one man, can cover the 10-acre block in 3 hours.

Orange County Records

Eight orchards are included in the tables for Orange County. Nos. 1, 2, 3, and 4 have been using oil for three years; the others for two years. Several growers in the county have followed this practice for longer periods; but labor and material cost figures were not available. The discussion of the San Bernardino records will apply generally to Orange County. Costs for the first year averaged \$25.59 per acre; for the second year \$21.80; for the third year \$15.34. All growers were thoroughly satisfied.

The complete data are given in tables 1 and 2.

Ventura County Records

The amounts of material used and the hours of labor required for Ventura County are shown at the bottom of table 2. Details of the individual blocks for this county are not given; only averages are presented. All records are for different blocks on one large ranch. Operations for the first year were not recorded. Those for the second year cover 17 separate blocks, a total of 267 acres; the third year, 8 separate blocks, 103.1 acres; the fourth year, 50.2 acres. Lemon, orange, grapefruit, and lime are the kinds of fruit grown. The trees were twelve to thirty years old. Considerable acreage is double-

planted and irrigated with a permanent sprinkler system, so that boom sprays could not be used. The soil, deep and rich, was heavily infested with weeds. Some of the blocks have steep slopes.

The costs on this record are much higher than the average for the other counties, owing to the double planting of trees, the permanent sprinkler system, and the heavy infestation of weeds.

General Observations on This Method in the Three Counties

Erosion: Growers reported that even on steep slopes, erosion was not so bad as under cultivation and covercropping. According to them the causes are, first, an improved water penetration, which reduces runoff; second, the firmness of the untilled surface.

Fertilization program: The growers using the system follow the usual practice of their district except that they do not raise covercrops nor work fertilizers into the soil.

Condition of trees: Growers were unanimous in their opinion that tree condition was improved.

Yield and quality of fruit and time of maturity: Some growers felt certain that yields were materially increased, although no figures have been gathered to establish this point. Some thought that they also had better-quality fruit. In several cases, maturity seemed to be advanced.

Condition of soil: Growers almost unanimously agreed that there was great improvement in the physical condition of the soil. Plow soles were eliminated within a few years. No one reported any detrimental effect from the oil.

Irrigation: It was generally agreed that the rate of water penetration was much improved--sometimes 100 per cent. Because of this improvement, some of the irrigation runs had to be shortened.

Organic matter: In this survey no attempt was made to determine the amount of organic matter in the soil; but neither was there any evidence that a lack had developed. Water penetration was improved, plow sole tended to disappear, and the physical condition of the soil was good. Judging from these observations, the organic matter was adequate for this method of soil management.

Capital investment: Investment in tractors and heavy tillage tools was reduced or eliminated, with resultant savings on interest, depreciation, and upkeep.

Other advantages: The work involved in picking, loading, and hauling fruit, pest control, pruning, and other operations is made much easier in weed-free orchards with firm surface soil than in orchards under different management. Picking crews and trucks can operate in noncultivated orchards one or two days after a heavy rain, which will leave tilled orchards too muddy to be worked in for a week or more.

Summary

Several thousand acres of citrus fruits are now under the noncultivation method of orchard management in which oil spray is used to control weeds. (No attempt was made to survey the actual number of acres.)

Orchard-heater oil is the usual material used for controlling weeds.

The most efficient rigs for spraying oil on weeds are those equipped with horizontal booms, and also with hose attachments that can be used for hand application.

Timeliness of application and careful planning of operations are highly important. Weeds should

be sprayed before they are 4 inches tall; or, if low-growing, before they bloom.

Where this method has been used, growers report improved soil condition, better tree condition, and increased yield. No detrimental effects have been observed to date. It should be noted, however, that the orchardists in this survey have used the oil-spray method for only a relatively short period.

The first and second years of operation are the period of heavy costs, after which the expense declines rapidly. As the tables show, this holds true for each group of records, as well as for all records combined.