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Oregon State College
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Charges for Commercially Applied Pesticides

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Introduction

Agriculture loses billions of dollars each year because of weeds, insects, and plant diseases. To combat this damage, the agricultural industry is using more chemicals. Applications are being made by both farmers and custom operators. The latter type is increasing rapidly, both by "ground" and "air" treatment.

Conservative estimates of pest damage reveal a staggering total of 10 to 12 billions of dollars annually. This is significant when compared with the approximately 33 billion dollars of 1955's total gross income for farmers. Without the various control measures now used, existence of our intensive type of agriculture would be seriously threatened, if not completely crippled.

Oregon's losses, as caused by weeds, insects, and diseases are currently estimated to be over $100,000,000. Losses are basically due to (1) competition for moisture and plant food, (2) attacks on the plant's structure, and (3) damage or injury to the product. Resulting damage includes watershed impairment, soil erosion, forage losses to livestock and game, and decreases in values of recreational areas.

Pesticides[1] developed slowly. Common salt is believed to have been the first chemical used to control weeds. Start of chemical control as we know it came in 1850 with the use of carbon bisulphide which would kill certain weedy plants if injected into the soil. Several basic chemicals such as copper solutions, sulfur, lime, lead arsenate, and sodium chlorate gradually came into use as control measures. Development in 1938 of Sinox (dinitro ortho cresol), a selective weed killer, gave new impetus to the investigations. During the second world war, extensive experiments on chemicals such as 2,4-D and DDT were successfully carried on. Since 1945 great advances have been made in effectively controlling pests with chemicals.

Attempts were made in 1918 to control insects by dumping poison dust from airplanes while flying over crops. By 1921, planes with special equipment had demonstrated their effectiveness for control of specific insect infestations. Airplanes and helicopters have now become commonplace tools in combating pests in this country.

The rapid development, and increasing use, of chemicals in farming have been among the major advances in technical agriculture during recent years. Growing complexity of chemicals and their ever more specific usage has led to development of pesticide specialists, both "air" and "ground." The trend now is for farmers to hire commercial applicators for pesticide work. Because pesticides have only recently assumed their important position, little information is available concerning their overall use. This study of commercial applicators in Oregon was made to find out (1) the acreages of specific crops treated, (2) pests attacked, (3) kinds and amounts of chemicals used, and (4) customary charges for different methods of application.

An analysis is presented concerning 2,252 jobs performed commercially on 108,549 acres in 1956. Results are cited from three sources; crops treated, pests attacked, and chemicals used. "Air" and "ground" applications are considered separately.

Based upon money charges found in this study, the majority of chemical control measures investigated would more than pay for themselves under average conditions.

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[1] Pesticides are chemicals or mixtures of chemicals, intended for use in controlling, preventing, destroying, or repelling pests. The term includes all insecticides, fungicides, herbicides, and defoliants applied to agricultural crops and land uses.

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Findings

During 1956, 19 commercial applicators sent descriptions of their daily chemical application jobs to Oregon State College to be summarized.

A total of 108,549 acres were involved, with air applications contributing 97,148 acres or about 90% of the acreage, but only 70% of the jobs. This is because the average size of an air job was 61.7 acres, compared with 16.8 acres for a ground job. The extreme difference in average size between "air" and "ground" jobs is quite important, and the size of jobs done by each group affected per acre charges for application. As a general rule, smaller jobs require higher charges, as illustrated by an average charge per acre of $2.04 for ground work, compared with $1.50 for air. (See table 1.)

For both ground and air, spraying was more common than dusting. Charges for spray applications per acre were substantially lower than for dusting. Fertilizing, seeding, and combinations of various operations represented only a small portion of the total sample. Per acre charges for these were slightly higher than for spraying, yet considerably lower than for dusting.

Representativeness of the sample

Work was concentrated in the Willamette Valley, Columbia Basin, central Oregon, and Snake River areas. Counties with the most acreage treated for weeds were Sherman, Umatilla, and Jefferson; for insects, Jefferson, Yamhill, and Benton; for disease, Yamhill, Marion, and Lane. The major fertilizer work was done in Linn, Umatilla, and Benton counties.

Approximately 19% of the total acreage to which chemicals were applied on a "custom" job basis in 1956 is included in this study. (See table 2.)

Overall generalized charges per acre

The average charge in 1956 for all chemical application work done was $1.56 per acre. (See table 1.) This includes pesticides, commercial fertilizers, from the air and from the ground, and dusting as well as spray jobs. Spray jobs were the most common because they are cheaper to apply, can be put on when there is more wind, and adhere longer than dusts. Average per acre charge for spraying was $1.42; for dusting, $2.28 (table 1).

Table 1. Summary of Work

Type of operation	No. of jobs	Total area	Area per job	Charge* per acre	Total application charges*
		Acres	*Acres*		
Air application					
Dusting	408	14,736	36.0	$2.26	$33,284
Spraying	927	60,330	65.1	1.33	80,210
Fertilizing	218	21,244	97.4	1.46	30,961
Other	20	838	41.9	1.44	1,204
Total	1,573	97,148	61.7	$1.50	$145,659
Ground application					
Dusting	62	347	5.6	$3.02	$ 1,050
Spraying	587	10,273	17.5	1.99	20,397
Fertilizing	27	680	25.2	2.43	1,656
Other	3	101	33.7	2.14	216
Total	679	11,402	16.8	$2.04	$ 23,319
Total ground and air applications					
Dusting	470	15,083	32.0	$2.28	$ 34,334
Spraying	1,514	70,603	46.6	1.42	100,607
Fertilizing	245	21,603	89.5	1.49	32,617
Other	23	939	40.8	1.51	1,420
Grand total	2,252	108,549	48.2	$1.56	$168,978

* Application charge does not include cost of chemical.

Table 2. Estimated Total Acres of Commercial Chemical Applications by Licensed Herbicide Operators Compared to Acreage Included in this Study

Type of operation	State Department of Agriculture survey	Corrected State Department estimate	OSC study	Total acreage in OSC study
	Acres	*Acres*	*Acres*	*Percent*
Dusting	80,868	80,868	15,083	18.6
Spraying	347,960	423,410	70,603	16.7
Fertilizing and Other	63,796	69,296	22,863	33.9
Total	592,624	573,574	108,549	18.9

Pest Control

Chemicals were applied for pest control on 85,658 acres, comprising 1,985 jobs. Seventy-one individual pests and 84 combinations were treated. Included were: 36 individual insects and 28 combinations of insects; 29 individual weeds and 50 combinations; and 6 separate diseases. Six combinations of the above jobs were also included.

Pest control is summarized under: (1) Crops and land uses treated, (2) Pests attacked, and (3) Chemicals used.

Crops and land uses treated

Every crop has at least one pest that can lower its production and reduce product quality. To meet this problem, chemicals are being used for control. Tabulations show that in 1956, 54 crops or land uses received some type of chemical treatment. Results of aerial application of dusts are shown in table 3.

Table 3. Summary of the Leading Crops Dusted by Air*

Crop or land use	No. of jobs	Total area	Av. area per job	Appl. charge per acre
		Acres	*Acres*	
Canning peas	88	3,590	40.8	$2.43
Vetch	70	2,132	30.5	1.89
Field peas	64	1,460	22.8	1.91
Snap beans	51	1,875	36.8	2.46
Cherries	30	1,016	33.8	2.77
All others	105	4,664	44.4	2.21
Total	408	14,736	36.1	$2.26

* These data extracted from table 5.

The three leading crops, canning peas, vetch, and field peas, were treated for the same insect type—pea weevil and vetch weevil. These crops comprised half the total acreage dusted by air.

Dusting with ground equipment was limited. Filberts were the only crop on which any substantial work was done and its relative importance is shown in table 4.

Table 4 shows the average application charge for "all others" as $5.78 per acre. This relatively high figure was influenced by inclusion of such expensive "per acre" jobs as city lawns, school grounds, fence rows, rights of way, and irrigation ditches.

Table 4. Summary of Important Dust Applications by Ground Rigs*

Crop or land use	No. of jobs	Total area	Av. area per job	Appl. charge per acre
		Acres	*Acres*	
Filberts	43	268	6.2	$1.77
All others	19	79	4.1	5.78
Total	62	347	5.6	$3.02

* These data extracted from table 5.

Air and ground dusting operations compared

It is difficult to make significant comparisons between dusting jobs as done by air and by ground applicators, because few crops were dusted to any extent by both means. (See table 5.) On the average, ground dusting was cheaper than air application. This is a complete reversal of the usual situation, and perhaps explains why most orchard work was done by ground operators.

Spraying

Included are 108,549 total acres of commercial work. Spray treatment was used on 65%, comprising 45 of the 54 different crops and land uses. This was the most important way of applying pesticides for several reasons.

(1) Spraying is cheaper than dusting. Disregarding the fact that different chemicals may have been used, the overall per acre charge was substantially lower. The average per acre charge for spray application was $1.42, as contrasted with the average dusting charge of $2.28 per acre. Chemicals used in pesticide work are either liquid concentrate or wettable powder. For dusts, the concentrated chemical is mixed in a "carrier material" such as talc. Cost, therefore, includes concentrate, talc, and transportation. The concentrated chemical for spray may be purchased without additional expense, since water can be added any time.

(2) Spray may be applied under a wider set of conditions. Dusts are more subject to drift and do not adhere as well as sprays. Also, spraying can be done under conditions that would be too windy for dust.

(3) Because of better adherence, sprays last longer—a critical factor in controlling some pests.

Table 5. Summary of All Chemical Work Done by Crop and Land Use

Crop or land use	Ground application				Air application			
	No. of jobs	Total area	Av. area per job	Av. appl. charge per acre	No. of jobs	Total area	Av. area per job	Av. appl. charge per acre
		Acres	*Acres*			*Acres*	*Acres*	
Dusting								
Alfalfa	.....	.....	.....	.....	4	354.0	88.5	$2.12
Clover	.....	.....	.....	.....	6	98.0	16.3	1.50
Field peas	.....	.....	.....	.....	64	1,459.5	22.8	1.91
Vetch	.....	.....	.....	.....	70	2,132.0	30.5	1.89
Other grasses	.....	.....	.....	.....	3	149.5	49.8	2.41
Root crops	.....	.....	.....	.....	2	36.0	18.0	1.50
Peppermint	.....	.....	.....	.....	5	506.0	101.2	2.55
Hops	.....	.....	.....	.....	6	180.0	30.0	1.50
Other specialty field and drug crops	.....	.....	.....	.....	1	40.0	40.0	2.50
Cherries	6	19.5	3.2	$2.31	30	1,015.5	33.8	2.77
Peaches	3	14.0	4.7	2.00	.....	.....	.....	.....
Prunes and plums	4	33.0	8.2	1.67	2	22.0	11.0	1.91
Other tree fruits	4	4.5	1.1	4.44	.....	.....	.....	.....
Filberts	43	268.5	6.2	1.77	7	126.0	18.0	2.37
Blackberries (tame)	.....	.....	.....	.....	3	27.0	9.0	2.93
Strawberries	.....	.....	.....	.....	23	979.0	42.6	2.30
Other small fruits	.....	.....	.....	.....	3	44.0	14.7	2.95
Beans	.....	.....	.....	.....	51	1,875.0	36.8	2.46
Beets	.....	.....	.....	.....	1	15.0	15.0	2.67
Cabbage	.....	.....	.....	.....	1	6.0	6.0	5.00
Carrots	.....	.....	.....	.....	1	12.0	12.0	3.75
Cauliflower	.....	.....	.....	.....	1	6.0	6.0	1.67
Corn (green)	.....	.....	.....	.....	1	35.0	35.0	2.00
Onions	.....	.....	.....	.....	1	19.0	19.0	1.47
Peas	.....	.....	.....	.....	88	3,590.5	40.8	2.43
Potatoes	.....	.....	.....	.....	24	1,505.5	62.7	2.09
Rhubarb	.....	.....	.....	.....	2	131.5	65.8	2.09
Other vegetables	.....	.....	.....	.....	3	103.0	34.3	2.83
Nursery crops	.....	.....	.....	.....	1	19.0	19.0	4.11
Flower bulbs, corms, and seeds	.....	.....	.....	.....	2	40.0	20.0	2.55
Other uses	2	7.8	3.9	54.62	1	8.0	8.0	3.25
Combinations of different crops	.....	.....	.....	.....	1	202.0	202.0	2.00
Dust Total	62	347.3	5.6	$3.02	408	14,736.0	36.1	$2.26
Spraying								
Barley	55	902.6	16.4	$1.25	29	2,663.2	91.8	$1.17
Corn	21	317.9	15.1	2.15	2	302.0	151.0	1.13
Oats	37	490.2	13.2	1.12	2	226.2	28.3	1.26
Wheat	50	671.3	13.4	1.69	151	26,194.5	173.5	1.11
Grain mixtures	15	461.5	30.8	1.29	14	1,883.0	134.5	1.16
Other grains	83	1,814.6	21.9	1.28	1	17.0	17.0	.....
Alfalfa	2	25.0	12.5	2.16	9	325.4	36.2	0.94
Clover	27	374.4	13.9	1.96	92	2,101.0	22.8	1.83
Field peas	2	32.0	16.0	2.72	67	1,531.5	22.9	1.49
Vetch	.....	.....	.....	.....	160	6,690.5	41.8	1.46
Other legumes	.....	.....	.....	.....	1	35.0	35.0	1.74
Bentgrass	3	268.9	89.6	1.54	3	435.0	145.0	1.00
Bluegrass	1	5.6	5.6	1.96	5	102.0	20.4	1.54
Fescue	8	159.0	19.9	1.75	18	1,269.0	70.5	1.12
Ryegrass	.....	.....	.....	.....	37	3,197.0	86.4	1.14
Sudan	3	32.0	10.7	1.31	1	64.0	64.0	1.25
Other grasses	3	85.1	28.4	2.12	3	92.0	30.7	1.54
Root crops	.....	.....	.....	.....	4	122.0	30.5	2.25
Pastures usually cultivated	5	57.7	11.5	1.92	1	194.0	194.0	1.25
Idle land or summer fallow	21	145.2	6.9	2.01	14	1,490.0	106.4	1.11
Peppermint	11	485.0	44.1	2.04	....	.....	.....	.....
Sugar beets	.....	.....	.....	.....	1	14.0	14.0	1.50
Other specialty field and drug crops	.....	.....	.....	.....	6	148.0	24.7	2.50

Table 5. (Continued)

Crop or land use	Ground application				Air application			
	No. of jobs	Total area	Av. area per job	Av. appl. charge per acre	No. of jobs	Total area	Av. area per job	Av. appl. charge per acre
		Acres	*Acres*			*Acres*	*Acres*	
Cherries	1	22.0	12.0	2.00	.....	.....	.....	.....
Prunes and plums	1	22.0	22.0	4.55	.....	.....	.....	.....
Other tree fruits	2	7.5	3.8	2.00	.....	.....	.....	.....
Filberts and hazelnuts	2	23.0	11.5	1.57	.....	.....	.....	.....
Walnuts	2	23.0	11.5	1.09	.....	.....	.....	.....
Cranberries	.....	.....	.....	.....	1	120.0	120.0	4.50
Strawberries	61	618.2	10.1	3.95	1	40.0	40.0	2.38
Asparagus	1	17.0	17.0	2.76	.....	.....	.....	.....
Beans	28	1,038.3	37.1	2.27	5	53.0	10.6	1.72
Beets	2	30.0	15.0	4.07	17	409.0	24.1	2.33
Cabbage	.....	.....	.....	.....	2	28.0	14.0	2.50
Corn (green)	36	1,382.4	38.4	2.17	8	527.0	65.9	1.42
Peas	5	147.5	29.5	2.92	76	2,425.0	31.9	1.94
Potatoes	19	249.8	13.1	2.34	147	5,627.0	38.3	1.76
Spinach	1	9.0	9.0	2.22	.....	.....	.....	.....
Other vegetables	.....	.....	.....	.....	8	80.5	10.1	2.24
Nursery crops	1	1.5	1.5	2.00	.....	.....	.....	.....
Permanent pasture	16	133.0	8.3	2.35	1	7.0	7.0	1.00
Rangeland	1	2.0	2.0	5.00	13	920.0	70.8	1.47
Timber	.....	.....	.....	.....	1	25.0	25.0	2.48
Other uses	61	228.6	3.7	5.54	5	81.0	16.2	1.74
Combinations of different crops	.....	.....	.....	.....	15	891.5	59.4	1.75
Spray								
Total	587	10,272.8	17.5	$1.99	927	60,330.3	65.1	$1.33
Dust and Spray								
Grand total	649	10,620.1	16.5	$2.02	1,335	75,066.3	56.2	$1.57

Aerial application of sprays

Sprays from the air were applied to 34 different crops and land uses, covering 60,000 acres in several parts of Oregon. Leading crops are shown in table 6.

Aerial applications of spray to wheat constituted 24% of the total acreage for the entire sample. Other leading crops were largely legumes such as vetch, field peas, and clover.

Job size ranged from 7 to 194 acres. Charges for specific crops varied depending on the crop or land use. For instance, the charge was $0.94 to treat alfalfa (table 5), while for cranberries it was $4.50 per acre.

Average charges for aerial application of sprays were considerably more than for ground applications.

Ground application of sprays

Spray applications by ground rigs were made on 34 different crops or land uses. Over 10,000 acres were covered in 587 jobs (table 7). Most ground work was done in the Willamette Valley where smaller acreages and intensified crop production allow ground men to compete more effectively with commercial airmen. Leading crops sprayed by ground applicators are entirely different from those sprayed by "air." This can be seen by checking tables 6 and 7.

In table 7, "other" grains includes all jobs designated simply as "grain," and involves buckwheat, emmer, millet, and speltz. It does not include wheat, oats, corn, barley, and rye.

Table 6. Summary of Leading Crops Treated by Aerial Application of Sprays*

Major crops	No. of jobs	Total area	Av. area per job	Av. appl. charge†
		Acres	*Acres*	
Wheat	151	26,194	173.5	$1.11
Vetch	160	6,690	41.8	1.46
Potatoes	147	5,627	38.3	1.76
Clover	92	2,101	22.8	1.83
Field peas	67	1,532	22.9	1.49
All other	310	18,186	58.6	1.39
Total	927	60,330	65.1	$1.33

* These data extracted from table 5.
† Application charges do not include cost of chemical.

Table 7. Summary of Leading Crops or Land Uses Sprayed From the Ground

Major crops	No. of jobs	Total area	Av. area per job	Av. appl. charge
		Acres	*Acres*	
"Other" grains	83	1,815	21.9	$1.28
Strawberries	61	618	10.1	3.95
"Other" uses	61	229	3.7	5.54
Barley	55	903	16.4	1.25
Wheat	50	671	13.4	1.68
All other	277	6,038	21.8	2.00
Total	587	10,273	17.5	$1.99

Table 8. Summary of All Fertilizer and "Other" Work Done by Crop and Land Use

Crop or land use	Ground Application				Air Application			
	No. of jobs	Total area	Av. area per job	Av. appl. charge per acre	No. of jobs	Total area	Av. area per job	Av. appl. charge per acre
		Acres	*Acres*			*Acres*	*Acres*	
Fertilizing								
Barley	.....	.....	.....	.....	2	82.0	41.0	$1.80
Oats	.....	.....	.....	.....	1	7.5	7.5	1.47
Wheat	.....	.....	.....	.....	35	7,862.0	224.6	0.95
Grain mixtures	.....	.....	.....	.....	4	378.5	94.6	1.15
Other grains	.....	.....	.....	.....	3	81.0	27.0	1.43
Alfalfa	.....	.....	.....	.....	1	9.0	9.0	2.22
Clover	.....	.....	.....	.....	3	133.5	44.5	1.65
Vetch	.....	.....	.....	.....	1	50.0	50.0	1.24
Bluegrass	.....	.....	.....	.....	4	87.0	21.8	1.49
Fescue	.....	.....	.....	.....	5	610.0	122.0	1.37
Ryegrass	.....	.....	.....	.....	135	10,560.5	78.2	1.86
Other grasses	.....	.....	.....	.....	2	150.0	75.0	2.51
Pastures	.....	.....	.....	.....	6	211.0	35.2	1.43
Idle land	.....	.....	.....	.....	6	771.0	128.5	1.06
Peppermint	.....	.....	.....	.....	2	48.0	24.0	1.60
Other tree fruits	.....	.....	.....	.....	1	14.0	14.0	1.71
Filberts and Hazelnuts	1	4.5	4.5	$2.44	.....	.....	.....	.....
Strawberries	25	668.4	26.7	2.43	.....	.....	.....	.....
Beans	.....	.....	.....	.....	2	32.0	16.0	1.72
Beets	.....	.....	.....	.....	2	123.0	61.5	1.10
Potatoes	1	7.5	7.5	2.93	2	23.5	11.8	0.34
Other uses	.....	.....	.....	.....	1	10.0	10.0	1.80
Total	27	680.4	25.2	$2.43	218	21,243.5	97.4	$1.46
Other—seeding								
Clover	.....	.....	.....	.....	1	120.0	120.0	$1.00
Ryegrass	.....	.....	.....	.....	10	383.0	38.3	1.34
Other grasses	.....	.....	.....	.....	3	80.0	26.7	1.61
Permanent pasture (non-tillable)	.....	.....	.....	.....	1	60.0	60.0	2.00
Total	.....	.....	.....	.....	15	643.0	42.9	$1.37
Other—fertilizing and seeding								
Clover	.....	.....	.....	.....	1	37.0	37.0	$1.51
Ryegrass	.....	.....	.....	.....	2	56.0	28.0	1.75
Beans	.....	.....	.....	.....	1	20.0	20.0	2.30
Total	.....	.....	.....	.....	4	113.0	28.2	$1.77
Other—fertilizing and pesticide spraying								
Ryegrass	.....	.....	.....	.....	1	82.0	82.0	$1.50
Strawberries	2	91.1	45.6	$2.15	.....	.....	.....	.....
Other uses	1	10.0	10.0	2.00	.....	.....	.....	.....
Total	3	101.1	33.7	$2.14	1	82.0	82.0	$1.50
"Other" Total	3	101.1	33.7	$2.14	20	838.0	41.9	$1.43
Fertilizer and "Other" Total	30	791.5	26.4	$2.36	238	22,081.5	92.7	$1.45

Ground and air spraying compared

Ground and air spray applications can be compared by considering crops treated by both methods. Table 5 is designed to show the same data for both "ground" and "air" on specific crops, and by method of application.

Nearly all legume and grass spray-work was done from the air, with the exception of clover treatments which were done by both methods. All work on tree-fruits and nuts was done from the ground. Most of the remaining types of crops and land uses had both air and ground applications.

Fertilizer

Commercial application of fertilizers has become an important part of the overall business of many of the custom operators, so is included in the analysis. Since these are not chemicals in the same sense as pesticides, a special section is devoted to it. Fertilizer work is summarized as to crops receiving applications (table 8).

Wheat and ryegrass received 80% of the total fertilizer applications, done entirely by aerial methods. Strawberries were the major crop fertilized with ground equipment. Usually charges for applying fertilizer were substantially less than for applying dusts, a similar type of work.

Some jobs, such as pesticide and fertilizer applications were combined and applied simultaneously. Seeding may also be included under the "other" classification. Practicality of some of these operations is not known; however, there has been a need to reseed ranges and forest lands, and the airplane has proved useful in this type of work.

"Seeding" and "seeding and fertilizing" made up most of the "other" type of operations. In these categories 756 acres were treated in 19 jobs. Most of the seeding was ryegrass (table 8).

Consideration of Specific Crops

Ten representative crops, including wheat, ryegrass, vetch, clover, cherries, filberts, strawberries, beans, canning peas, and potatoes, were selected for more detailed analysis. Selection was based on amounts of custom work done within major groupings.

Work done on each crop is summarized according to the purposes of applications. Shown within each pest group are total acres, and number of jobs done with each chemical or fertilizer, including number of pounds applied per acre as well as application charge.

Wheat

Most commercial work was done on wheat. Nearly 32% of 34,728 acres received custom work, either in the use of herbicides, or fertilizers. Table 9 summarizes these applications.

Table 9. Wheat—Summary of All Commercial Work Done

Pest or operation	Chemical or fertilizer	Area treated	No. of jobs	Chemical applied per acre	Av. charge* for appl. per acre
		Acres		*Pounds*	
Fertilizer	Ammonium Nitrate	7,564	31	69.0	$ .95
Fertilizer	Urea	36	3	87.0	1.25
Fertilizer	Anhydrous Ammonium	262	1	69.0	1.00
Tarweed	2,4-D	3,431	12	.8	1.06
Tarweed and mustard	2,4-D	6,028	29	.9	1.14
Tarweed-Knotweed	2,4-D	3,889	10	.7	1.02
Mustard	2,4-D	1,713	12	1.0	1.16
Mustard combination	2,4-D	6,140	28	.8	1.08
Russian Thistle-Knotweed	2,4-D	71	1	1.1	1.10
Canada Thistle	2,4-D	695	17	.9	1.27
Canada Thistle comb.	2,4-D	575	15	.9	1.51
Vetch	2,4-D	140	10	1.0	1.83
Morning Glory	2,4-D	205	2	.9	1.13
Lambs Quarter	2,4-D	481	17	.8	1.50
Lambs Quarter comb.	2,4-D	700	4	.6	1.06
Pigweed	2,4-D	29	2	.9	1.69
Pigweed	Dinitro General	20	1	1.0†	2.50
Pigweed-Fanweed	2,4-D	106	1	.8	1.09
Weeds (unnamed)	2,4-D	2,005	27	.8	1.21
Weeds (unnamed)	Dinitro Amine	11	1	4.5	2.00
Weeds (combination)	2,4-D	172	5	1.1	1.43
Weeds (vetch)	MCP	9	1	.2	2.04
Knotweed	2,4-D	358	2	.7	1.10
Sunflower	2,4-D	61	1	.9	1.10
Radish	2,4-D	14	1	1.0	1.00
Star Thistle	2,4-D	14	2	1.0	2.07
Total		34,728	236	.....	$1.09

* Application charge does not include cost of chemical.
† Indicates number of quarts.

Ryegrass

Ryegrass represents commercial work done on grasses. All work was done by aerial application, with specific jobs listed in table 10. In 185 jobs 14,278 acres of ryegrass were treated. Work included fertilizing, "other," and weed control.

Table 10. Ryegrass—Summary of All Commercial Work Done

Pest or operation	Chemical or fertilizer	Area treated	No. of jobs	Chemical applied per acre	Av. charge* for appl. per acre
		Acres		*Pounds*	
Fertilizer	Amm. Phosphate	745	4	195.0	$1.95
	Amm. Phosphate-Amm. Nitrate	57	1	135.0	1.60
	Amm. Phos.-Urea	174	2	172.0	1.96
	Amm. Sulfate	5,290	76	186.0	2.07
	Amm. Sulfate-Nitrate	75	1	168.0	1.93
	Amm. Sulfate-Nitrate-Urea	143	1	100.0	1.25
	Amm. Sul.-Urea	1,313	16	268.0	1.84
	Amm. Nitrate	1,493	21	113.0	1.32
	Nitrate-Calcium Nitrate	70	1	121.0	1.45
	Urea	1,123	12	120.0	1.63
	Uran	54	1	45.0	1.50
	Superphosphate	79	1	243.0	2.43
Other	Seeding	383	10	20.2	1.34
Vetch	2,4-D	60	1	1.0	1.50
Garlic-Onion	2,4-D	356	11	1.4	1.60
Weeds (unnamed)	2,4-D	407	7	1.2	1.36
Weeds (unnamed)	2,4-D, Nitrate Solution	82	1	.7	1.50
Grass	Chloro IPC	2,374	18	2.0	1.02
Total		14,278	185	.....	$1.68

* Application charge does not include cost of chemical.

Vetch

This study involved 8,872 acres of vetch in 231 jobs (table 11). Commercial chemical applications included fertilizer, defoliation, and insect control.

Over 96% of the total work done on vetch was to control the weevil. DDT was the most common chemical used. It was applied at an average rate of .9 pound to the acre, for which an average application charge of $1.55 was made.

Table 11. Vetch—Summary of All Commercial Work Done

Pest or operation	Chemical or fertilizer	Area treated	No. of jobs	Chemical applied per acre	Av. charge* for appl. per acre
		Acres		*Pounds*	
Fertilizer	Gypsum	50	1	100.0	$1.24
Defoliation	Dinitro General	93	4	1.4†	2.50
Leaf Tier	Malathion	19	2	1.3	1.58
Weevil	DDT	8,540	219	.9	1.55
Weevil	DDT-Parathion	42	1	.....	1.76
Weevil-Aphid	DDT	45	1	1.0	1.40
Weevil-Aphid	DDT-Parathion	8	1	.....	1.75
Weevil-Pea Weevil	DDT	75	2	.8	1.89
Total		8,872	231	.....	$1.56

* Application charge does not include cost of chemical.
† Indicates number of quarts.

Clover

Clover (including red, crimson, ladino, and alsike) received fertilizing, seeding, defoliation, weed, and insect control. A total of 2,864 acres of clover was treated in 130 jobs. Average charge was $1.79 an acre. Table 12 summarizes commercial work done.

Table 12. Clover—Summary of All Commercial Work Done

Pest or operation	Chemical or fertilizer	Area treated	No. of jobs	Chemical applied per acre	Av. charge* for appl. per acre
		Acres		*Pounds*	
Fertilizer	Ammonium Sulfate	22	1	138.1	$1.64
	Ammonium Nitrate	37	1	100.0	1.51
	Superphosphate and Boron	12	1	213.9	2.35
	Lime	100	1	157.0	1.57
"Other"	Seeding	120	1	9.2	1.00
Vetch	MCP	284	10	.4	2.04
Vetch and Mustard	2,4-D	13	1	1.0	1.00
Garlic and Onion	2,4-D	13	1	4.0	3.54
Weeds (unnamed)	MCP	4	1	.2	2.00
Grass	Chloro IPC	130	2	3.5	1.29
Grass	IPC	3	1	4.6	2.31
Defoliation	Dinitro General	522	27	1.4†	2.40
Lygus bug	DDT	104	6	2.0	1.75
Lygus bug	Toxaphene	119	8	3.3	1.77
Lygus and Midge	DDT	69	4	1.5	1.60
	DDT-Sulphur	12	1	.....	1.50
	Aldrin	18	1	.5	1.78
	Toxaphene	729	30	3.0	1.63
	Toxaphene-DDT	4	1	.....	1.75
	Toxaphene-Aldrin	15	2	.....	1.73
Lygus and Weevil	DDT	73	2	1.2	1.54
Lygus and Weevil	Toxaphene	160	6	3.0	1.76
Lygus and Weevil	Aldrin	15	1	1.0	1.00
Nitidulids	DDT	15	1	1.5	1.87
Nitidulids	Toxaphene	58	4	2.4	1.62
Lygus and others	Toxaphene	43	3	3.0	1.60
Weevil	Toxaphene	35	1	3.0	1.74
Weevil and Mites	DDT-Sulfur	12	1	.....	1.50
Insects (unnamed)	DDT	60	5	2.2	1.73
Insects (unnamed)	DDT-Malathion	8	1	.....	1.12
Insects (unnamed)	Toxaphene	29	1	3.0	1.76
Clover Root-Borer	Aldrin	18	2	1.0	1.00
Strawberry root-weevil	Aldrin	8	1	2.0	2.00
Total		2,864	130	.....	$1.79

* Application charge does not include cost of chemical.
† Indicates number of quarts.

Cherries

Commercial chemical application work done on cherries was limited. However, treatment usually meant the difference between a saleable product and a complete loss. Applications were made for the control of diseases, weeds and insects. A total of 1,047 acres was included, and average per acre charge for all custom work was $2.75. (See table 13.)

Table 13. Cherries—Summary of All Commercial Work Done

Pest or operation	Chemical or fertilizer	Area treated	No. of jobs	Chemical applied per acre	Av. charge* for appl. per acre
		Acres		*Pounds*	
Brown Rot	Sulfur	11	2	45.4	$2.00
Weeds (unnamed)	2,4-D	12	1	1.1	2.00
Caterpillar	Kolokill	23	1	50.0	3.26
Caterpillar	Rotenone	473	2	30.0	2.49
Caterpillar	DDT-Sulphenone	10	1	.....	3.00
Cherry Fruitfly	Kolokill	354	20	44.0	3.35
Cherry Fruitfly	Lead Arsenate	20	1	20.0	3.25
Syneta Beetle	DDT	53	1	1.8	2.00
Syneta Beetle	Kolokill	87	6	43.9	2.87
Leaf Tier	Kolokill	4	2	50.0	2.50
Total		1,047	37	.....	$2.75

* Application charge does not include cost of chemical.

Filberts

Filberts had the least commercial treatment. A total of 422 acres received custom work in 53 jobs. Average per acre charge for all these was $1.95. Table 14 shows that the only applications of consequence were for insect control.

Table 14. Filberts—Summary of All Commercial Work Done

Pest or operation	Chemical or fertilizer	Area treated	No. of jobs	Chemical applied per acre	Av. charge* for appl. per acre
		Acres		*Pounds*	
Fertilizer	Ammonium Nitrate	4	1	178.0	$2.44
Brush	2,4-D	10	1	1.2	1.60
Caterpillars (tent)	Lead Arsenate	14	1	40.0	3.00
Filbert Moth	DDT-Malathion	50	1	.....	1.76
	DDT	36	4	2.1	1.83
	Lead Arsenate	163	20	16.3	2.12
	Lead Arsenate-copper	3	1	.....	2.00
Filbert leaf-roller	DDT (TDE)	47	5	1.9	1.60
Filbert leaf-roller	DDT	84	15	2.1	1.75
Leaf Roller-caterpillar	DDT	1	1	2.0	5.00
Tier	DDT	5	1	2.0	2.00
Tier	Lead Arsenate	5	2	1.6	2.20
Total		422	53	.....	$1.95

* Application charge does not include cost of chemical.

Strawberries

Total custom applications to strawberries were on 2,397 acres and totaled 112 jobs (table 15). Work consisted of fertilizing and defoliation, and weed, disease, and insect control. Cost of application was $2.75 per acre.

In all, 23 chemicals or chemical combinations were used.

Table 15. Strawberries—Summary of All Commercial Work Done

Pest or operation	Chemical or fertilizer	Area treated	No. of jobs	Chemical applied per acre	Av. charge* for appl. per acre
		Acres		*Pounds*	
Fertilizer	Ammonium Phosphate	2	1	200.0	$4.00
	Urea	656	23	48.0	2.41
	Urea-IPC	91	2	.....	2.15
	Uran	10	1	11.0	3.00
Annual Bluegrass	ATA-Dalapon	2	1	.....	†
Pigweed	2,4-DS	25	4	2.4	2.20
Weeds (unnamed)	Dinitro Amine	32	4	3.0	4.23
Weeds (unnamed)	Dinitro General	13	2	1.4‡	5.69
Weeds (unnamed)	Dinitro General-IPC	4	2	.....	3.33
Defoliation	Dinitro Amine	60	8	2.6	4.50
Defoliation	Dinitro General	283	19	1.4‡	4.84
Fruit Rot	Captan	10	1	2.0	2.00
Fruit Rot	Ziram	36	2	3.8	2.50
Mildew	Captan	3	1	2.7	5.00
Leaf Tier	Captan	49	3	1.9	3.10
	DDT	349	5	2.0	2.17
	DDT-Copper-Sulfur	50	1	.....	2.00
	DDT-Malathion-Ziram	10	1	.....	2.50
	DDT-Ziram	386	3	.....	2.17
	Malathion	53	2	2.0	3.11
	Meticide	4	1	2.5	3.75
	Methoxychlor	7	1	2.6	3.28
	Sulfur	10	1	40.0	3.00
Strawberry Root Weevil	Aldrin	107	1	4.4	2.38
Strawberry Root Weevil	Chlorodane	95	3	3.0	2.50
Strawberry Root Weevil	Heptachlor	31	9	7.4	2.96
Symphyllids	Parathion	6	1	5.0	3.00
Worms	Kolokill	12	1	50.0	3.25
Total		2,397	112	.....	$2.75

* Application charge does not include cost of chemical.
† The ATA-Dalapon job on annual bluegrass was done on an experimental basis and no charge made.
‡ Indicates number of quarts.

Beans

Custom work on beans consisted of fertilizing and chemical controls for disease, weeds, and insects, with the latter of primary importance. Average charge for all applications was $2.37 an acre. Table 16 is a complete summary of all custom work done on beans.

Table 16. Beans—Summary of All Commercial Work Done

Pest or operation	Chemical or fertilizer	Area treated	No. of jobs	Chemical applied per acre	Av. charge* for appl. per acre
		Acres		*Pounds*	
Fertilizer	Nitrate	40	2	150.0	$2.08
Fertilizer	Boron	12	1	41.7	1.50
Mold	Ziram	10	1	5.2	1.50
Morning Glory	2,4-D	3	1	2.0	2.00
Pigweed	Alanap	3	1	1.3	2.67
Pigweed	Dinitro Amine	19	2	3.9	2.47
Weeds (unnamed)	2,4-D	38	1	1.0	2.43
Weeds (unnamed)	Dinitro Amine	968	21	1.3	2.25
Aphid	Malathion	432	14	2.0	2.22
	Methoxychlor	26	3	1.9	2.54
	TEPP	64	5	.5	3.92
	Copper-Sulfur-DDT	132	1	.....	2.00
Aphid-Spt. Beetle	Malathion	93	6	1.9	2.94
Cucumber Beetle	DDT	49	6	1.9	3.14
	DDT-Copper	98	1	.....	2.00
	DDT-Sulfur	8	1	.....	3.00
	Malathion	190	2	1.7	2.28
	Methoxychlor	10	2	2.0	3.60
	Sulfur	92	1	40.0	2.25
	TEPP	46	1	.4	3.73
Cucumber Beetle-Nitidulids	DDT-Parathion	115	2	.....	2.41
Beetles (unnamed)	Copper-Sulfur-DDT	42	1	.....	2.76
Nitidulids	DDT	14	2	1.8	3.14
Nitidulids	Malathion	5	1	2.0	3.00
Nitidulids	TEPP	40	2	.4	4.22
Slugs	Bait	50	2	10.0	1.26
Symphyllids	Parathion	8	2	5.0	3.25
Total		3,018	87	.....	$2.37

* Application charge does not include cost of chemical.

Canning Peas

Commercial chemical applications on canning peas were herbicides or insecticides. On 169 jobs, a total of 6,163 acres was treated at an average charge of $2.24 per acre (table 17). The pea weevil was the chief pest. DDT and Malathion were the main chemicals used.

Table 17. Canning Peas—Summary of All Commercial Work Done

Pest or operation	Chemical or fertilizer	Area treated	No. of jobs	Chemical applied per acre	Av. charge* for appl. per acre
		Acres		*Pounds*	
Pigweed	Dinitro General	50	2	1.1†	$2.50
Weeds (unnamed)	2,4-D	430	2	1.0	1.00
Weeds (unnamed)	Dinitro General	44	2	1.1†	2.50
Weeds (unnamed)	Dinitro Amine	148	5	.8	2.92
Aphids	Parathion	591	14	.5	2.49
Pea Weevil	DDT	2,110	109	1.3	1.87
	Malathion	1,716	8	2.0	2.67
	Malathion-Rotenone	401	2	.....	2.93
	Parathion	255	7	.4	2.50
Weevil-Aphid	DDT-Sulfur	16	1	.....	1.50
Weevil-Aphid	Malathion	72	2	1.2	1.45
Weevil-Aphid	Parathion	331	15	.5	2.50
Total		6,163	169	.....	$2.24

* Application charge does not include cost of chemical.
† Indicates number of quarts.

Potatoes

Potatoes received a variety of commercial work, although most of it was for insect control. Other types of applications were fertilizer, weed and disease control, and defoliation. In the 194 jobs done, 7,498 acres were covered at an average application charge of $1.84 per acre (table 18).

Table 18. Potatoes—Summary of All Commercial Work Done

Pest or operation	Chemical or fertilizer	Area treated	No. of jobs	Chemical applied per acre	Av. charge* for appl. per acre
		Acres		*Pounds*	
Fertilizer	Urea	24	2	101.0	$0.34
Fertilizer	Nitrogen Solution	8	1	11.0	2.93
Inhibit sprouting	MH-40	64	1	7.0	2.15
Defoliation	Dinitro General	4	1	.8†	4.00
Defoliation	Sodium Arsenate	139	15	4.0	2.50
Blight	Copper-DDT	146	4	.....	2.51
Blight	Dithane	308	4	1.0	2.11
Blight	Zineb	430	3	2.4	2.25
Blight-Mosquitoes	Sulfur-Copper-DDT	100	1	.....	2.25
Aphid-"Beetles" and Leaf Hoppers	DDT	2,564	74	1.5	1.70
	Malathion	37	1	1.0	1.76
	DDT-Malathion	1,957	53	.....	1.69
	DDT-Parathion	310	13	.....	1.70
	DDT-Sulfur	178	4	.....	1.44
Tuber Flea Beetle	DDT	51	1	1.0	2.50
Tuber Flea Beetle	DDT-Copper	36	1	.....	2.50
Tuber Flea Beetle	Aldrin	42	2	2.4	1.93
Roller	DDT	71	1	.8	1.74
Roller	DDT-Malathion	352	3	.....	1.75
Wireworm	Aldrin	322	4	1.8	2.39
Wireworm	Dithane	165	1	1.0	2.00
Insects (unnamed)	DDT	9	1	1.6	1.77
Wireworm-Flea Beetle	Aldrin	160	1	1.9	2.37
Insects (unnamed)	DDT-Sulfur	22	2	.....	1.50
Total		7,498	194	.....	$1.84

* Application charge does not include cost of chemical.
† Indicates number of quarts.

Economic Aspects of Pesticide Application

For each of the 10 crops just discussed, total costs of typical control measures are shown in table 19. These costs are shown in relation to the amount of increased production needed to pay for the control measures. Representative pests were chosen, and the price for the important chemical used on each pest determined from price lists of chemical companies. Chemical price and charge for application were added to obtain the total charge per acre.

The average price used for each crop is the 5-year (1952-1956) average price received by Oregon farmers. These prices have been reduced to a per pound basis to measure the exact amount of increased yield necessary to pay for chemical pest control.

Some pests were easily controlled with light applications of inexpensive chemicals, such as DDT and 2,4-D. Other pests required heavier applications or expensive chemicals to get the desired control. Prices ranged from $1.65 to $12.06 per application (table 19).

Some pests, such as the cherry fruitfly, required successive chemical applications within a single season, while others could be controlled by one application during the life of the crop. To get an accurate estimate on the total cost of controlling various pests, the number of applications per year must be added when there is more than one, and when a residual chemical control is used, cost must be pro-rated for the years of its effective life.

Effectiveness of chemical control measures applied to insects is difficult to estimate. Environmental conditions such as available moisture or prevailing temperatures during the host's growing season, may exert a great influence on how pests react to treatments.

Many crops in the study were grown in widely different areas of Oregon, and results may only be indicative of local conditions and could vary with locality. This is especially true of herbicide work.

Insects and diseases cause losses primarily through damage to some part of the structure of the plant or to the product for which the crop is grown. The latter is more readily evident and usually is the reason for insecticide application, for it may mean the difference between a saleable product and a partial or complete loss.

Where the product can be sold if sorted, loss comes in two forms; in a direct loss of income for all the product that must be sorted out as unacceptable, and additional operational expense of the sorting process. These losses can be reduced with timely chemical applications.

Net economic advantage of pest control

Data in table 19 present an estimate of how much additional product is needed to pay for control of selected pests on each of ten crops. Note how small the required yields (last column, table 19) are in every case. One of the best examples is cherries. In cherries, control of the fruitfly is necessary if the crop is to be sold. Usually three applications of chemicals are necessary to effect satisfactory control. Assuming that three applications of Kolokill were made at $7.75 (table 19) per application, total cost of control measures would be $23.25 per acre. It would take 175 pounds of cherries to pay for controls, if cherries sold for 13.3¢ per pound. Assuming 50 cherry trees per acre, only 3.5 pounds of cherries from each tree would pay for all the chemical control measures for the cherry fruitfly. Without this control, the crop cannot be sold.

It is self-evident that weeds growing with a crop compete directly and effectively for plant nutrients and soil moisture. Weed control increases production, and decreases product contamination with foreign materials, thus improving the product's quality and value.

Control of annual grasses in ryegrass has this dual purpose because as a seed crop the ryegrass must be uncontaminated. Using chloro IPC for this purpose, the chemical and its application cost $4.42 an acre. If ryegrass sold for 10.4¢ (table 19), an estimated 42.5 pounds of the crop would pay for the control. Even with ryegrass selling for 4.5¢ a pound, 100 pounds would more than pay for the chemical treatments. Not only is yield per acre increased when annual grasses are controlled, but seed quality is also improved. Eighteen farmers in this study paid for the application of chloro IPC to 2,374 acres.

Table 19. Economic Aspects of Pesticide Applications

Crop and pest	Chemical used	Total chemical and application charge per acre (per application)			Average farm price for crop (5-year average) (1952-56)	Increase in per acre yield needed to pay for control
		Appl.	Chem.	Total		
		Dollars				
Wheat						
Tarweed-Mustard	2,4-D	1.14	.64	1.78	$0.035 per pound or	50.80 pounds
Mustard-Combination	2,4-D	1.08	.57	1.65	$2.10 per bushel	47.10 pounds
Ryegrass (Perennial)						
Annual Grasses	Chloro IPC	1.02	3.40	4.42	$0.104 per pound	42.50 pounds
Weeds (unnamed)	2,4-D	1.36	.85	2.21		21.25 pounds
Vetch						
Weevil	DDT	1.55	.50	2.05	$0.058 per pound	35.30 pounds
Clover						
Midge and Lygus	Toxaphene	1.63	1.83	3.46	$0.25½ per pound	13.60 pounds
Vetch	MCP	2.04	3.12	3.12		12.20 pounds
Cherries						
Caterpillar	Rotenone	2.49	3.90	6.39	$0.133 per pound	48.00 pounds
Cherry Fruitfly	Kolokill	3.35	4.40	7.75		58.25 pounds
Filberts						
Filbert Moth	Lead Arsenate	2.12	4.89	7.01	$0.185 per pound	38.40 pounds
Filbert Leaf Roller	DDT	1.75	1.16	2.91		12.40 pounds
Strawberries						
Root Weevil	Aldrin	2.38	9.68	12.06	$0.165 per pound	73.20 pounds
Leaf Tier	DDT	2.17	1.10	3.27		19.80 pounds
Beans						
Aphids	Malathion	2.22	4.42	6.64	$0.64 per pound or	103.70 pounds
Weeds (unnamed)	Dinitro Amine	2.25	2.21	4.46	$128.32 per ton	69.60 pounds
Canning Peas						
Weeds (unnamed)	2,4-D	1.00	.71	1.71	$87.32 per ton or	38.80 pounds
Weevil	DDT	1.87	.72	2.59	$0.044 per pound	58.80 pounds
Weevil	Malathion	2.67	4.42	7.09		161.00 pounds
Potatoes						
Aphids, Flea Beetles, and Leaf Hoppers	DDT	1.70	.82	2.52	$2.07 per cwt. or	120.00 pounds
Wireworm	Aldrin	2.39	3.96	6.35	$0.021 per pound	302.30 pounds

An example of actual results from chemical weed controls is from experimental data on wheat. A 3-year average of the yield increases resulting from weed control on the Pendleton and Sherman Branch Experiment Stations ranged from a 1½-bushel increase at Union to a 16-bushel increase at the Pendleton station. On the average, slightly over four additional bushels of wheat per acre can be expected from weed control. Table 19 indicates that cost of both the chemical and its application would be more than paid for if increased wheat yield only amounted to one bushel. The price of one bushel is not too much to pay for a possible increase of four bushels.

Pests Attacked

Reported pesticide applications were used to control pests that attack agricultural crops. Pests treated were insects, weeds, and plant diseases. The chemical treatments for each pest group will be discussed separately.

Table 20 lists all of the insects, diseases, and weeds that were chemically treated by custom operators. Timing of chemical applications for pest control is of vital importance in obtaining maximum protection to agricultural crops. In herbicide application, physiology of both weed plant and crop must be considered. Timing will vary with the weed to be controlled, the crop involved, and specific chemical used.

For convenience in recording data sent in from the field, each month was divided into two parts. This procedure tends to present a longer "time range" than was often the case. For example, if one job was done on June 15, and another of the same type was done on June 16, the first job would be recorded as having been done in the first part of June (June 1 to June 15), and the latter job would have been recorded in the latter part of June (June 16 to June 30). In table 20, this example would be shown with a time range of June 1 to June 30, whereas it occurred on two consecutive days.

Some chemicals are used to control several different weeds, and some weeds are pests to more than one crop. This situation results in a longer time range than would otherwise be the case.

A total of 85,658 acres was chemically treated in 1,985 jobs to control 65 individual pests and 84 combinations of pests. Forty-two single chemicals and 38 combinations of chemicals were applied.

Insects

By acreage, the three most important insects combatted with chemical treatments were vetch weevils, pea weevils, and aphids (table 21). These jobs were all done by air operators. Combined vetch and pea weevil treatments constituted nearly half of the total insect work done. For these two, a total of 15,061 acres were treated in 463 jobs. Other leading insects were aphids and aphids-beetles combination.

In all, 36 varieties of insect pests and 28 combinations of various insect pests were treated with 22 different chemicals or chemical combinations, DDT and Malathion being most commonly used. The number of insect jobs was 1,033 on 33,000 acres—38.5% of the complete pesticide sample.

Spraying done from the air amounted to a total of 60,330 acres. This method was used on the largest percentage of acres in the entire study.

Aerial view of pest control work done by dusting methods. A total of 15,736 acres was treated with commercially applied chemicals in this study.

Table 20. Summary of All Pests Treated

Pest	Time range	Number of jobs		Area treated		Chemical used
		air	ground	air	ground	
				Acres	*Acres*	
Insects						
Aphid	June 1-Oct. 15	123	....	4,314	....	Copper, DDT, Sulfur, Malathion, Parathion, TEPP, Systox, Methoxychlor
Flea Beetles	Apr. 16-Aug. 31	5	1	113	27	Aldrin, DDT
Mint Flea Beetles	July 1-July 15	4	....	266	....	DDT, Malathion
Syneta Beetles	Apr. 16-May 15	7	1	140	22	DDT, Kolokill
Tuber Flea Beetles	May 16-Aug. 15	2	1	87	16	Aldrin, Copper, DDT
Dibratica (spotted cucumber beetle)	May 16-Aug. 15	20	....	1,012	....	Sulfur, Copper, DDT, Metacide, TEPP, Malathion, Methoxychlor
Beetles (unidentified)	June 16-July 31	26	....	837	....	Sulfur, Copper, DDT
Clover Root Borer	Apr. 16-Apr. 31	....	2	....	18	Aldrin
Peach and Prune Root Borer	July 16-July 31	....	1	....	22	DDT
Borers (unidentified)	May 1-May 15	2	....	27	....	Malathion
Lygus Bugs	May 16-July 31	19	....	506	....	Aldrin, DDT, Sulfur, Toxaphene
Tent Caterpillar	May 1-May 31	5	....	520	....	DDT, Kolokill, Lead Arsenate
Cherry Fruitflies	May 16-June 31	20	2	393	5	Kolokill, Lead Arsenate
Grasshoppers	July 16-Aug. 15	10	....	481	....	Aldrin
Leaf Hoppers	June 1-June 15	....	1	....	8	Malathion
Onion Maggot	Apr. 16-Apr. 30	1	....	19	....	DDT
Spider Mites	July 16-July 31	1	....	19	....	Malathion, TEPP
Mites (unidentified)	May 1-May 15	2	....	72	....	2,4-D, Sulfur
Mosquitoes	Apr. 16-May 31	2	....	33	....	DDT
Filbert Moth	May 1-July 31	6	20	112	140	DDD, DDT, Copper, Malathion, Lead Arsenate
Nitidulids	May 1-July 31	10	....	133	....	DDT, Malathion, TEPP, Toxaphene
Slugs	May 1-June 15	2	....	50	....	Bait
Symphyllids	Apr. 16-June 15	....	2	....	13	Parathion
Filbert Leaf Roller	Apr. 16-May 15	....	20	....	131	DDD, DDT
Roller (unidentified)	May 16-July 31	4	1	423	1	DDT, Lead Arsenate, Malathion
Tier, Omniverous Leaf	Apr. 16-Aug. 15	23	6	1,075	16	Captan, DDT, Kolokill, Copper Sulfate Lead Arsenate, Malathion, Sulfur, Metacide, Ziram, Methoxychlor
Thrip	Apr. 16-June 31	2	....	26	....	DDT, Kolokill
Clover Leaf Weevil	Apr. 16-Apr. 30	....	1	....	15	Aldrin
Pea Weevil	May 16-July 31	243	....	7,019	....	DDT, Malathion, Parathion, Rotenone
Strawberry Root-Weevil	Apr. 1-Sept. 15	1	21	40	201	Aldrin, DDT, Chlordane, Heptachlor
Vetch Weevil	May 16-June 31	220	....	8,583	....	DDT, Parathion
Weevils (unidentified)	June 16-June 31	1	....	35	....	Toxaphene
Cutworms	Apr. 16-July 31	6	1	202	3	Aldrin, DDT
Wireworms	Apr. 16-May 31	5	....	487	....	Aldrin, Dithane
Worms (unidentified)	May 1-July 31	4	2	148	2	DDD, DDT, Kolokill, Parathion, TEPP
Insects (unnamed)	June 1-Sept. 30	12	1	144	13	Aldrin, DDT, Malathion, Sulfur, Toxaphene
Two insects						
Aphids-Flea Beetles	July 1-July 31	3	....	70	....	DDT, Malathion, Parathion
Aphids-Diabratica	July 16-Aug. 15	9	....	493	....	DDT, Malathion
Aphids-Beetles (unidentified)	July 16-July 31	33	....	965	....	DDT, Malathion, Parathion, Sulfur
Aphids-Lygus Bugs	July 16-July 31	4	....	224	....	DDT, Malathion, Toxaphene

Table 20. (continued)

Pest	Time range	Number of jobs		Area treated		Chemical used
		air	ground	air	ground	
				Acres	*Acres*	
Aphids-Horn Flies	June 16-June 30	1	....	42	....	DDT, Malathion
Aphids-"Flies"	July 1-July 15	1	....	10	....	DDT, Malathion
Aphids-Leaf Hoppers	July 16-July 31	3	....	178	....	DDT, Malathion
Aphids-Midge	June 16-July 15	3	....	269	....	DDT, Malathion, Toxaphene
Aphids-Alfalfa Weevil	June 16-June 31	....	1	....	17	Aldrin, Malathion
Aphids-Wireworms	June 1-June 15	1	....	202	....	DDT, Captan, Diathone, Sulfur
Diabratica-Mosquitoes	July 1-July 15	1	....	98	....	DDT, Copper, Sulfur
Diabratica-Nitidulids	July 1-July 15	1	....	17	....	DDT, Parathion
Lygus Bugs-"Beetles"	July 16-July 31	1	....	20	....	DDT
Lygus Bugs-Clover Flower Midge	July 1-July 31	4	....	69	....	DDT
Lygus Bugs-"Midge"	June 16-July 31	37	....	879	....	Aldrin, DDT, Sulfur, Toxaphene
Lygus Bugs-Thrip	June 16-July 15	2	....	11	....	DDT, Toxaphene
Lygus Bugs-Alfalfa Weevil	July 1-July 15	1	....	5	....	DDT
Lygus Bugs-Clover Leaf Weevil	June 1-July 31	3	....	91	....	DDT, Toxaphene
Lygus Bugs-Clover Seed Weevil	July 16-July 31	1	....	10	....	Toxaphene
Lygus Bugs-"Weevils"	June 1-June 31	5	....	174	....	DDT, Malathion, Toxaphene
Spider Mites-O. B. Leaf Roller	May 16-May 31	1	....	10	....	Sulfur
Filbert Leaf Roller-Tent Cat.	May 1-May 15	....	1	....	1	DDT
Pea Weevil-Aphids	May 16-July 15	23	....	586	....	DDT, Malathion, Parathion, Sulfur
Pea Weevil-Vetch Weevil	May 16-June 15	8	....	343	....	DDT
Vetch Weevil-Aphids	May 16-June 31	2	....	53	....	DDT, Parathion
Weevils-Aphids	July 1-July 15	1	....	78	....	DDT
Weevils-Mites	June 1-June 15	1	....	12	....	DDT, Sulfur
Wireworms-Flea Beetle	May 16-May 31	1	....	160	....	Aldrin
Insects—subtotal		947	86	32,379	668	
Weeds						
Tarweed	Mar. 16-May 30	12	....	3,431	....	2,4-D
Mustard	Mar. 16-July 15	14	8	2,359	73	2,4-D
Russian Thistle	May 16-May 30	1	....	178	....	2,4-D
Vetch	Jan. 1-June 15	6	20	1,850	380	2,4-D, MCP
Morning Glory	Mar. 16-Sept. 30	12	6	1,948	26	2,4-D
Canadian Thistle	May 1-Sept. 15	23	57	1,263	542	2,4-D, ATA, MCP, 2,4-D, 2,4-5T Brush Killer
Garlic-Onions	Apr. 1-May 31	11	1	320	13	2,4-D
Lambs Quarter	May 31-July 1	19	10	542	139	2,4-D
Annual Bluegrass	Apr. 1-Apr. 15	....	1	....	2	ATA, Dalapon
Cheatgrass	Apr. 1-Apr. 15	1	....	45	....	Dalapon
Tussock	Apr. 16-June 1	....	2	....	16	2,4-D
Poison Oak	Feb. 1-June 1	....	2	....	4	2,4-D, 2,4-5T
Wild Blackberry	June 1-Sept. 1	....	3	....	17	2,4-5T Brush Killer (2,4-D and 2,4-5T)
Sagebrush	May 1-June 1	10	....	725	....	2,4-D
Tansy Ragwort	June 30-Aug. 1	2	1	55	50	2,4-D
Sheep Sorrel	Apr. 15-Apr. 30	....	1	....	35	2,4-D
Quackgrass	Apr. 30-May 31	....	3	....	9	2,4-D, ATA, Ammate, Dalapon
Hemlock	Apr. 15-Apr. 30	....	1	....	1	2,4-D
Pigweed	May 1-Aug. 15	4	8	82	148	2,4-D, 2,4-DS, Alanap, Dinitro Amine, Dinitro General

Table 20. (continued)

Pest	Time range	Number of jobs		Area treated		Chemical used
		air	ground	air	ground	
				Acres	*Acres*	
Yellow Star Thistle	Apr. 16-Apr. 31	....	3	....	20	2,4-D
Willow	June 16-June 30	1	....	36	....	2,4-D
Knotweed	Apr. 16-May 15	3	....	433	....	2,4-D
Weeds (unnamed)	Apr. 1-Nov. 30	49	228	3,930	5,210	Brush Killer, 2,4-D, ATA, 2,4-DS, Dinitro General, IPC, CMU, DCMU, Dinitro Amine, Sodium Chlorate
Grass	Mar. 1-Nov. 30	43	17	4,217	535	Chloro IPC, DCMU, 2,4-D, ATA, Dalapon
Brush	May 16-Aug. 31	1	1	15	10	2,4-D, Brush Killer
Radish	May 1-July 1	....	23	....	337	2,4-D
Nettles	May 1-May 15	1	....	7	....	2,4-D
Sunflower	July 16-July 31	1	....	61	....	2,4-D
Defoliation	June 16-Nov. 15	22	53	525	582	Dinitro Amine, Dinitro General, Sodium Arsenate
Two weeds						
Canada Thistle-Filaree	June 16-June 30	1	....	62	....	2,4-D
Canada Thistle-Vetch	May 1-May 31	4	1	92	10	2,4-D
Canada Thistle-French Pink	May 1-May 15	....	1	....	21	2,4-D
Canada Thistle-Morning Glory	June 1-Sept. 15	1	5	27	58	2,4-D
Canada Thistle-Lambs Quarter	May 16-June 15	....	2	....	40	2,4-D
Canada Thistle-Poison Oak	June 16-June 30	....	1	....	8	2,4-D
Canada Thistle-Wild Blackberry	Apr. 16-Aug. 15	....	7	....	34	2,4-D, 2,4-5T, Brush Killer
Canada Thistle-Poison Oak	June 16-June 30	....	1	....	8	2,4-D
Canada Thistle-Tansy Ragwort	June 16-June 30	....	1	....	3	2,4-D
Canada Thistle-Pigweed	May 1-June 1	....	5	....	102	2,4-D
Canada Thistle-Weeds	May 1-June 30	6	12	511	304	2,4-D, Brush Killer
Canada Thistle-Grass	May 16-May 31	....	1	....	1	Ammate, Dalapon
Canada Thistle-Radish	May 1-June 30	....	12	....	243	2,4-D, ATA
Garlic or Onions-Vetch	Apr. 16-May 15	2	....	83	....	2,4-D
Garlic or Onions-Canada Thistle	May 16-May 31	1	....	40	....	2,4-D
Garlic or Onions-Weeds	Apr. 16-Apr. 30	1	....	110	....	2,4-D
Lambs Quarter-Mustard	May 1-June 31	1	1	32	15	2,4-D
Lambs Quarter-Russian Thistle	June 1-June 15	1	....	15	....	2,4-D
Lambs Quarter-Pigweed	May 16-June 15	1	2	33	34	2,4-D
Lambs Quarter-Weeds	May 16-May 31	1	....	620	....	2,4-D
Lambs Quarter-Radish	May 1-May 15	....	1	....	18	2,4-D
Cheatgrass-Ryegrass	Apr. 16-Apr. 30	1	....	60	....	2,4-D, Dalapon
Tussock, Radish	June 16-June 30	....	1	....	10	2,4-D
Cattails-Weeds	May 1-May 15	....	1	....	2	Ammate, Dalapon
Dandelion-Plantain	June 16-June 30	....	1	....	33	2,4-D
Hemlock-Dandelion	Apr. 16-Apr. 30	....	1	....	4	2,4-D
Pigweed-Sunflower	July 1-July 31	1	....	10	....	2,4-D
Yellow Star Thistle-Mustard	Apr. 16-May 31	....	2	....	29	2,4-D
Yellow Star Thistle-Brush	July 16-July 31	....	1	....	3	Brush Killer
Weeds (unnamed)-Mustard	Apr. 16-June 31	1	2	90	22	2,4-D
Grass-Wild Blackberry	June 1-June 15	....	1	....	5	2,4-D, 2,4-5T, Dinitro General
Tarweed-Mustard	Apr. 1-May 31	34	1	7,411	6	2,4-D
Tarweed-Filaree	Apr. 16-Apr. 30	1	....	80	....	2,4-D

Table 20. (continued)

Pest	Time range	Number of jobs: air	Number of jobs: ground	Area treated: air	Area treated: ground	Chemical used
				Acres	*Acres*	
Tarweed-Knotweed	Apr. 1-May 31	9	....	3,809	....	2,4-D
Mustard-Russian Thistle	May 16-May 31	2	....	3,745	....	2,4-D
Mustard-Vetch	May 1-May 31	....	3	....	43	2,4-D
Mustard-Morning Glory	May 1-June 30	....	7	....	67	2,4-D
Mustard-Canada Thistle	May 16-July 15	26	2	1,850	61	2,4-D
Mustard-Pigweed	May 1-May 15	1	....	551	....	2,4-D
Mustard-Radish	June 1-June 15	....	1	....	60	2,4-D
Filaree-Russian Thistle	May 1-May 15	1	....	210	....	2,4-D
Russian Thistle-Knotweed	May 1-May 15	1	....	70	....	2,4-D
Vetch-Weeds (unnamed)	Apr. 1-Apr. 30	....	4	....	48	2,4-D, MCP
Morning Glory-Pigweed	June 1-June 15	....	1	....	76	2,4-D
Grass-Weeds	Feb. 1-Sept. 15	....	21	....	128	Dinitro General, CMU, DCMU, Polybor, 2,4-D, 2,4-5T, ATA, Borate, Borascu, chlorate, Dalapon
Brush-Weeds	May 1-Aug. 31	....	2	....	5	Brush Killer
Sunflower-Mustard	June 16-June 30	1	....	248	....	2,4-D
Sunflower-Weeds	July 1-July 15	1	....	95	....	2,4-D
Fanweed-Pigweed	June 16-June 30	1	....	106	....	2,4-D
Defoliation-Weeds	July 1-July 15	....	2	....	27	Dinitro General
Fanweed-Weeds	June 16-June 30	1	....	23	....	2,4-D
Weeds—subtotal		330	555	40,339	9,649	
Diseases						
Mold	June 1-Sept. 15	8	....	153	....	Captan, Malathion, Sulfur, TEPP, Ziram
Fruit Rot (Strawberry)	June 1-June 15	2	....	36	....	Ziram
Brown Rot (Cherry)	Apr. 16-June 30	....	5	....	25	Sulfur
Rot	Aug. 1-Aug. 31	....	3	....	11	Sulfur
Mildew	May 1-Aug. 15	13	....	354	....	Captan, Copper Sulfate, Diathone, Sulfur
Fire Blight	July 16-Aug. 31	11	....	884	....	Copper, DDT, Dithane, Zineb
Rust-Weeds	May 1-May 15	....	1	....	277	Dinitro Amine
Lygus Bugs-Lambs Quarter	June 1-June 15	2	....	39	....	DDT, Toxaphene, 2,4-D
Walnut Blight-Mosquitoes	July 1-July 15	1	....	100	....	Copper, DDT, Sulfur
Leaf Spot-Aphids	July 16-July 31	6	....	182	....	DDT, Malathion, Parathion
Rust-Mint Flea Beetle	July 16-July 31	1	....	240	....	DDT, Dichlone
Leaf Spot-Lygus Bugs	July 1-July 31	14	....	323	....	Copper, Sulfate, DDT, Parathion, Copper
Diseases—subtotal		58	9	2,310	313	
Grand—total		1,335	650	75,028	10,630	
Grand—total (air and ground)		1,985		85,658		

Table 21. Summary of Leading Insects Receiving Chemical Treatments*

Leading insects	No. of jobs	Area treated	Time range for treatments	Chemicals used
		Acres		
Weevil (vetch)	220	8,582	May 16-June 30	DDT, Parathion
Weevil (pea)	243	7,019	May 16-July 31	DDT, Malathion, Parathion, Rotenone
Aphids	123	4,314	June 1-Oct. 15	Copper, DDT, Sulfur, Malathion, Parathion, TEPP, Systox, Methoxychlor
Aphids-Beetles	33	965	July 16-July 30	DDT, Malathion, Parathion, Sulfur
Lygus-Midge	37	879	June 16-July 31	Aldrin, DDT, Sulfur, Toxaphene

* These data extracted from table 20.

Weeds

Over 58% (50,088 acres) of the chemical pesticide treatments were for purposes of controlling 29 separate varieties of weeds and 50 weed combinations. This work was done in 885 jobs—55 by "ground" and 330 by "air." Over 90% of the total ground chemical work and well over half of the air work was for weed control, giving a good representative picture of herbicide applications in Oregon. The only chemical of real importance, considering acreages treated, was 2,4-D, either alone or in combinations.

"Weeds (unnamed)," was a category used by applicators when they did not know the specific variety of weed or weeds they were treating or when they were treating several kinds at once. Most of the "weed" treatments were done by ground equipment in the Willamette Valley, where smaller jobs predominated and a diversity of weeds was found. Emphasizing the importance and diversity of weed control problems in Oregon, note that eleven chemicals were used for control purposes, extending over a period of eight months (table 22).

The classification, grass, included treatments ranging from annual grasses in perennial grass-seed crops to jobs such as grass growing around buildings and along roadways. Seven different chemicals were applied during a 9-month period.

Tarweed, in combination with mustard and with knotweed, growing in cereal crops (primarily wheat) in eastern Oregon, constituted 11,000 acres in 44 jobs. The herbicide 2,4-D was used exclusively, and was applied on dates ranging from April 1 to May 30. Application dates recommended by Oregon State College for these conditions are from March 15 to April 15. Treatments after the latter date usually do not give satisfactory control.

Table 22. Summary of Leading Weeds Receiving Chemical Treatments*

Leading weeds	No. of jobs	Area treated	Time range for treatments	Chemicals used
		Acres		
Weeds (unnamed)	277	9,140	Apr. 1-Nov. 30	IPC, Brushklr., 2,4-D, CMU, ATA, DCMU, 2,4-DS, Dinitro Amine, Dinitro General
Grass	60	4,752	Mar. 1-Nov. 30	Chloro IPC, IPC, DCMU, 2,4-D, Dalapon
Tarweed-Mustard	35	7,471	Apr. 1-May 30	2,4-D
Tarweed-Knotweed	9	3,810	Apr. 1-May 30	2,4-D

* These data extracted from table 20.

Plant diseases

Fifteen chemicals were used either separately or in combinations to control plant diseases. Table 23 presents a summary of the major pests of this type.

The combination treatment of leaf spot (a disease) and lygus bug (an insect) is a good example of how two different pest types can be attacked at the same time if the chemicals are compatible. For other combinations, see table 20.

Table 23. Summary of Leading Disease Pests Receiving Chemical Treatment*

Leading diseases	No. of jobs	Area treated	Time range for treatments	Chemicals used
		Acres		
Fire Blight	11	884	July 16-Aug. 31	Copper, DDT, Dithane, Zineb
Mildew	13	354	May 1-Aug. 15	Captan, Copper, Sulfate, Diathone, Sulfur
Mold	8	153	June 1-Sept. 15	Captan, Malathion, Sulfur, TEPP, Ziram
Leaf Spot and Lygus Bug	14	323	July 1-July 31	Copper, Sulfate, DDT, Parathion, Copper

* These data extracted from table 20.

Chemicals Used

For pest control, 42 individual chemicals and 38 combinations of 2, 3, and 4 chemicals were used. Chemicals for pest control are called pesticides. The term includes all insecticides, fungicides, herbicides, and defoliants applied to agricultural crops.

Many commercially applied pesticides are dangerous to humans, livestock, and various forms of plant life; therefore, extreme caution must be used to safeguard against harmful effects. State and Federal governments have developed regulations for applying pesticides which are rigidly enforced to safeguard the public. Commercial applicators of herbicides in the state of Oregon are required to pass a written examination and obtain a license for themselves and their equipment. Airmen must have special permits to drop any material from their planes. Chemical producers must label pesticide ingredients and give directions for proper use. Food products going on the consumer market must pass toxicity tests when they have been chemically treated.

Table 24 summarizes pesticide materials applied to agricultural crops and land uses included in the 1956 study. The chemical 2,4-D (a weed killer) was the most important. In this study it was used to treat 35,690 acres in 602 jobs—mostly from the air. DDT was next, with 18,498 acres treated, mostly from the air.

Charges for chemical materials varied with kinds used, methods of application, and individual operators. Most of the chemicals used were supplied by the farmers, especially for "air" jobs. Where chemicals were applied both as dust and spray these are shown separately.

Table 24. Summary of All Chemicals Applied by Air and Ground

Chemical	Air method*	No. of jobs	Area treated	Chemical applied per acre	Application charges per acre	Chemical charges per acre‡
			Acres	*Pounds*		
2,4-D	S	259	35,127.5	.9	$1.14	$ .78
Aldrin	S	18	1,035.3	1.1	1.65	.47
Bait	D	2	50.0	10.0	1.26	....
Brush Killer (2,4-D, 2,4-5T)	S	1	15.0	4.0	1.47	8.13
Captan	D	5	62.0	1.9	3.02	....
Captan	S	4	109.0	1.5	2.50	2.48
(All Captan)		(9)	(171.0)	(1.7)	(2.69)	(2.48)
Chloro IPC	S	39	3,988.0	2.4	1.04	.23
Chloro IPC, IPC	S	1	18.0	....	1.00	....
Copper, DDT	D	6	279.5	....	2.33	....
Copper, DDT	S	8	190.0	....	2.49	....
(All Copper, DDT)		(14)	(469.5)	....	(2.38)	....
Copper, Sulfur, DDT	D	6	784.0	....	2.24	....
Copper Sulfate	D	1	25.0	2.0	2.00	3.20
Parathion	S	1	11.0	....	2.55	1.09
Dalapon	S	1	45.0	3.5	1.24	....
Dalapon, 2,4-D	S	1	60.0	....	1.25	1.08
DCMU	S	3	126.0	2.3	1.57	....
DDD	D	1	4.0	2.5	2.50	....
DDD, Malathion	D	1	50.0	....	1.76	....
DDT	D	239	5,851.5	1.0	1.95	.71
DDT	S	359	12,484.5	1.2	1.52	.63
(All DDT)		(598)	(18,336.0)	(1.2)	(1.66)	(.65)
Copper Sulfate, DDT	D	1	50.0	....	2.00	....
Copper Sulfate, DDT	S	5	122.0	....	2.50	....
(All Cop. Sul., DDT)		(6)	(172.0)	....	(2.35)	....
DDT, Dichlone	D	1	240.0	....	3.00	....
DDT, Diothone, Sulfur, Captan	D	1	202.0	....	2.00	....
DDT, Malathion	S	58	2,317.0	....	1.70	....
DDT, Malathion, Toxaphene	S	4	279.5	....	1.75	....
DDT, Malathion, Ziram	D	1	10.0	....	2.50	....
DDT, Metacide, TEPP	D	1	68.0	....	3.07	....
DDT, Parathion,	D	1	17.0	....	3.29	....
DDT, Parathion	S	18	398.0	....	1.72	1.67
(All DDT, Parathion)		(19)	(415.0)	....	(1.78)	(1.67)

Table 24. (continued)

Chemical	Air method*	No. of jobs	Area treated	Chemical applied per acre	Application charges per acre	Chemical charges per acre‡
			Acres	*Pounds*		
DDT, Sulfur	D	11	262.0	....	$1.50	....
DDT, Sulphenone	D	1	10.0	....	3.00	$4.00
DDT, Toxaphene	S	6	280.0	....	1.75	....
DDT, Ziram	D	5	522.0	....	2.12	....
Systox	S	7	137.0	.2	2.50	....
Dinitro General	S	27	639.0	1.4†	2.52	1.48
Diothone	D	6	180.0	.7	1.50	....
Dithane	D	5	473.0	1.0	2.07	....
IPC	S	2	136.0	2.0	1.00	....
Kolokill	D	28	506.5	44.7	3.13	4.00
Lead Arsenate	D	6	86.0	19.3	2.98	5.10
Malathion	D	37	2,596.0	2.0	2.56	3.44
Malathion	S	7	106.0	1.0	1.58	2.93
(All Malathion)		(44)	(2,702.0)	(2.0)	(2.52)	(3.32)
Malathion, DDT	D	2	165.0	....	2.88	....
Malathion, Rotenone	D	2	401.0	....	2.93	....
MCP	S	3	106.0	.5	2.00	....
Metacide	D	1	4.0	2.5	3.75	....
Methoxychlor	D	6	43.0	2.0	2.91	....
Parathion	S	40	1,402.0	.4	2.60	1.43
Rotenone	D	2	473.0	.3	2.50	....
Sulfur	D	9	306.5	40.7	2.50	....
TEPP	D	8	152.0	.4	4.03	8.00
TEPP	S	2	40.0	.4	2.50	2.67
(All TEPP)		(10)	(192.0)	(.4)	(3.71)	(3.29)
TEPP, Malathion	D	1	19.0	....	4.11	....
Toxaphene	D	4	360.0	3.9	2.09	....
Toxaphene	S	50	1,114.5	3.0	1.67	....
(All Toxaphene)		(54)	(1,474.5)	(3.3)	(1.78)	....
Toxaphene, 2,4-D	S	2	39.0	....	1.77	....
Toxaphene, Aldrin	S	2	15.0	....	1.73	....
Zineb	D	3	430.0	2.4	2.25	....
Ziram	D	3	46.0	4.1	3.17	....
Total—dust		408	14,736.0	3.6	2.26	.88
Total—spray		927	60,330.3	1.1	1.33	.76
Air subtotal, dust and spray		1,335	75,066.3			
	Ground method*					
2,4-D	S	343	563.0	.9	$1.55	$ .89
2,4-D, 2,4-5T	S	2	8.0	....	3.90	8.54
2,4-D, ATA	S	8	65.0	....	2.09	6.65
2,4-D, 2,4-DS	S	1	16.0	....	.62	1.00
2,4-D, Polybor	S	1	.3	....	60.00	146.67
2,4-DS	S	4	25.0	2.4	2.20	4.72
2,4-5T	S	3	2.0	7.1	27.65	22.35
Alanap	S	1	3.0	1.3	2.67	....
Aldrin	S	16	165.0	3.2	2.01	7.37
ATA	S	1	2.0	4.8	....	13.60
ATA, Dalapon	S	2	10.0	....	1.62	8.76
Borascu	D	1	.1	2,000.0	80.00	150.00
Brush Killer	S	18	77.0	2.3	2.78	3.39
Brush Killer, Nu Green (fert.)	S	1	10.0	....	2.00	5.40
Chlordane	S	3	95.0	3.0	2.51	13.47
Chloro IPC	S	7	368.0	2.1	1.59	3.31

* S-Spraying—D-Dusting
† Indicates number of quarts.
‡ Chemical charges are included only when the applicator furnished them.

Table 24. (Continued)

Chemical		No. of jobs	Area treated	Chemical applied per acre	Application charges per acre	Chemical charges per acre‡
CMU	S	20	170.0	2.9	$4.25	$12.75
CMU, Borate, Chlorate	D	1	8.0	....	54.29	....
CMU, DCMU	S	1	43.0	....	2.00	....
Dalapon, 2,4-D	S	1	1.0	....	2.00	33.00
Dalapon, 2,4-D, 2,4-5T	S	1	.1	....	60.00	130.00
Dalapon, Ammate	S	3	8.0	....	6.38	33.50
DCMU	S	1	.1	50.0	90.00	210.00
DDD	D	5	47.0	1.9	1.60	2.90
DDT	D	22	126.0	2.2	1.82	3.71
DDT	S	2	35.0	5.8	3.43	2.11
(All DDT)		(24)	(162.0)	(3.0)	(2.17)	(3.36)
Dinitro General	S	38	441.0	1.4†	4.01	4.88
Dinitro General, 2,4-D, 2,4-5T	S	1	5.0	....	2.20	9.40
Dinitro General, IPC	S	2	4.0	....	3.33	11.11
Dinitro Amine	S	55	2,424.0	1.7	2.32	3.07
Heptachlor	S	9	31.0	7.4	2.96	16.17
IPC	S	8	148.0	3.1	2.03	6.40
Kolokill	D	4	8.0	52.9	2.71	6.47
Lead Arsenate	D	20	118.0	17.6	1.84	6.98
Lead Arsenate, Copper	D	1	3.0	....	2.00	11.00
Malathion	S	1	8.0	1.0	2.50	.25
Malathion, Aldrin	S	1	17.0	....	2.00	....
MCP	S	12	231.0	.2	2.05	.67
MH-40	S	1	64.0	7.0	2.16	....
Parathion	S	3	14.0	5.0	3.14	4.12
Polybor	S	1	.1	500.0	70.00	80.00
Sulfur	D	8	36.0	49.0	2.00	3.17
Sodium Arsenate	S	15	139.0	4.0	2.51	1.10
Sodium chlorate	S	1	20.0	200.0	5.00	....
IPC, Nu Green (fert.)	S	2	91.0	....	2.15	....
Total—dust		62	347.3			
Total—spray		590	10,373.9			
Ground subtotal, dust and spray		652	10,721.2			
Grand total, ground and air		1,987	85,787.5			

S—Spraying. D—Dusting
* These data extracted from table 20.
† Indicates number of quarts.
‡ Chemical charges are included only when the applicator furnished them.

Aerial-applied pesticides

Nearly 88% (75,066 acres) of the total pesticide work was from the air (table 24). The 1,335 treatments (both spray and dust) included insecticides, herbicides, fungicides, and defoliants. For these purposes 29 single chemicals and 23 combinations were used. Leading chemicals are shown in table 25.

Table 25. Leading Chemicals Applied by Air*

Chemical	No. of jobs	Area treated	Average per acre: Chemical applied	Average per acre: Application charge	Average per acre: Chemical charges†
		Acres	*Pounds*		
Insecticides					
DDT	598	18,336	1.1	$1.66	$ .65
Malathion	44	2,702	2.0	2.52	3.32
Toxaphene	54	1,474	3.3	1.78	.....
Herbicides					
2,4-D	259	35,126	.9	1.14	.78
Chloro IPC	39	3,988	2.4	1.04	.....
Defoliants					
Dinitro General	27	639	1.4‡	2.52	1.48
Fungicides					
Sulfur	9	306	40.7	2.50	.....
Dithane	5	473	1.0	2.07	.....

* These data extracted from table 24.
† Chemical charges are included only when the applicator furnished them.
‡ Indicates number of quarts.

Ground-applied pesticides

About 12% (10,721 acres) of the total pesticide work was done with ground equipment. Treatments consisted of 652 jobs using herbicides primarily; yet including some insecticide, fungicide, and defoliant work. For ground control of pests 28 chemicals and 16 combinations of chemicals were employed. Table 26 shows leading chemicals used.

Table 26. Leading Chemicals Applied by Ground*

Chemical	No. of jobs	Area treated	Average per acre: Chemical applied	Average per acre: Application charge	Average per acre: Chemical charges†
		Acres	*Pounds*		
Insecticides					
DDT	24	162	3.0	$2.17	$3.36
Aldrin	16	165	3.2	2.01	7.37
Herbicides					
2,4-D	343	5,631	.9	1.55	.89
Dinitro Amine	55	2,424	1.7	2.32	3.07
Defoliants					
Dinitro General	38	441	1.4‡	4.01	4.88
Sodium Arsenate	15	139	4.0	2.51	1.10
Fungicides					
Sulfur	8	36	49.0	2.00	3.17

* These data extracted from table 24.
† Chemical charges are included only when the applicator furnished them.
‡ Indicates number of quarts.

Comparison of ground and air applications

In hiring agricultural chemical applications, a farmer can have it done by either ground or air operators. For this reason, comparison of rates charged by each group of operators is of interest.

Table 27 presents comparative data (air and ground) for the major chemical used as an insecticide (DDT); the major chemical used as an herbicide (2,4-D); and the major chemical used as a defoliant (Dinitro General). Average charges for ground custom operators were markedly higher than for air operators.

Commercial air applicators operate on an extensive scale. They are primarily concerned with large acreages over a wide area. The usual job size is large, travel time both to and from the individual job, and between jobs, is short, and there is no equipment to load or unload at every job. Because the equipment covers many acres in a short time, per acre cost is low and subsequently the charge to the farmer is also low.

Ground custom jobs are small as a rule, involving spot spraying, lawn work, or orchard work, all of which cannot be done effectively from the air. However, use of the helicopter is "moving in" on orchard applications. Ground rigs must be loaded or unloaded in moving to different jobs, and travel time between jobs is considerable. These factors increase cost to the applicator so he must charge more per acre for treatments made.

As job sizes get larger for both ground and air, charges per acre for application tend to decrease, but for every job size, average aerial charges per acre for application were markedly less than for ground operations.

Table 27. Comparison of Leading Chemicals Applied by Ground and Air

Chemical	Method of application	No. of jobs	Area treated	Average per acre: Chemical applied	Average per acre: Charge for* application
			Acres	*Pounds*	
DDT	Ground	24	162	3.0	$2.17
DDT	Air	598	18,336	1.1	1.66
2,4-D	Ground	343	5,631	.9	1.55
2,4-D	Air	259	35,126	.9	1.14
Dinitro General	Ground	38	441	1.4†	4.01
Dinitro General	Air	27	639	1.4	2.52

* Does not include cost of chemical.
† Indicates number of quarts.

Fertilizer Applications

Fertilizer applications represented an important part of some of the custom applicators' jobs. There were 22,000 acres of fertilizer work done, primarily by air. This was 20.5% of the total acreage. The airplane has advantages of applying fertilizers when soil conditions and growing crops are correct, if land is isolated and difficult to reach by ground, and when time saving is important. Air applications are made in bigger jobs, less time and labor are spent per acre, and a larger volume of business is done. This results in lower costs per acre and is usually reflected in a lower custom charge per acre to the farmer. Often fertilizer work is a seasonal fill-in to keep men and equipment busy, and also it may be a means of obtaining the farmer's chemical business later in the season.

Twenty-two crops or land uses had fertilizers applied with leading ones presented in table 28. Twelve different fertilizers were used, yet ammonium sulfate, ammonium nitrate, and urea were the only ones of importance (table 29). Over 2,000,000 pounds of fertilizer, mostly Ammonium Sulfate, was applied.

Table 28. Extent to Which Leading Crops Were Fertilized

Leading crops	No. of jobs	Area treated	Average job size	Average appl.* charge per acre
		Acres	*Acres*	
Ryegrass	138	10,698	77.5	$1.86
Wheat	34	7,862	231.2	.95
Summer Fallow	6	771	128.5	1.06
Strawberries	27	760	28.1	2.39
Fescue	5	610	122.0	1.37

* Does not include cost of chemical.

Table 29. Summary of Leading Fertilizers

Fertilizer	No. of jobs	Area treated	Total applied	Average applied per acre	Range per acre
		Acres	*Pounds*	*Pounds*	*Pounds*
Ammonium Sulfate	81	5,740	1,036,410	180.6	83 - 303
Ammonium Nitrate	73	10,520	856,280	81.4	50 - 211
Nu Green (Urea)	54	2,458	238,912	97.4	55 - 210
Total	208	18,718	2,131,602	.....	.....

Economics of pest control

Use of pesticides on crops is of little value to the farmer unless they can be applied economically. The number of pounds of additional produce required to pay for the chemical and its application on selected pests is computed in table 19. Compared with normal crop yields few pounds of produce were estimated to be required to pay for the pest control measures.

Though difficult to estimate, net financial returns to the farmer resulting from chemical control practices may mean the difference between a saleable product and partial or complete loss. Insect damage is the best example of this. If the cherry fruitfly is not controlled, the wormy crop cannot be marketed commercially—yet as little as 3½ pounds of cherries per tree (assuming 50 trees per acre) will pay the total cost of the chemical and the three applications usually necessary for its control.

For the 10 crops used as examples, cost of control of the major pests was low when computed in pounds of produce. The realized value-received varied from a few bushels' increase, as in wheat, to the value of the complete crop in the case of cherries. Based upon charges found in this study, the majority of chemical control measures studied in 1956 would more than pay for themselves under average conditions.

Appendix

Oregon has a herbicide law placing certain restrictions on commercial applicators. Each commercial applicator must annually obtain a special license issued by the State Department of Agriculture. Aerial operators must also meet requirements concerning registration and operation. Oregon's "Economic Poison Law" requires all chemical materials sold as pesticides to be properly labeled and to include directions for use.

In addition to these state laws, there is a federal law, "Public Law 518," commonly referred to as the "Miller Amendment," which sets up tolerances for individual pesticides in an effort to control the amount of residue

reaching consumers. Under this law, interstate food shipment bearing residues above established tolerances are contraband and subject to seizure as adulterated. The commercial chemical applicator, while not directly concerned with this loss to the farmer, depends on his patronage for continuing business. Obviously it is a good practice for the applicator to do all he can to help farmers comply with the law.

To obtain a herbicide license in Oregon, the commercial custom applicator must pass a written examination including questions about characteristics of pesticides and effects on crops; methods of application; conditions, timing, and precautions in using various chemicals; and laws, rules, and regulations on pesticide applications. The State Department of Agriculture, in cooperation with Oregon State College, sponsors a short course for chemical applicators doing custom work in Oregon.

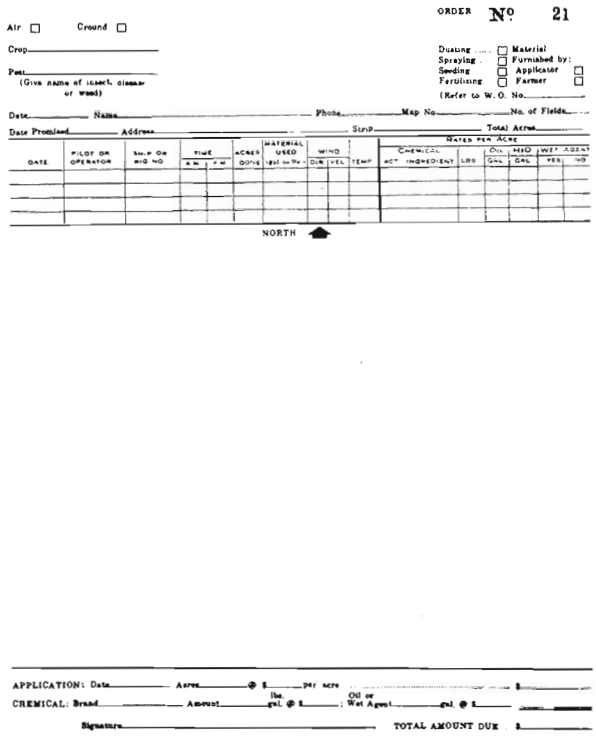
For several years there has been a continuing interest in starting a research program to study commercial application of agricultural chemicals in Oregon. In 1953, the Short Course planning committee discussed the need for an economic study on chemical applications. This might show in dollars and cents net benefits per acre of chemical applications, add to present knowledge of effectiveness of chemical applications, and provide facts for proposals by legislative committees.

The planning committee, which included men from the State Department of Agriculture, custom chemical applicators, and Oregon State College staff members, suggested that the college do preliminary work to determine feasibility of such a study. In the following two years, letters were sent to other states, chemical companies, and commercial applicators to determine what was being done elsewhere, and obtain suggestions as to methods and forms best adapted. The final result was development of a work sheet which was a practical business form for the chemical applicator, containing information needed for a comprehensive research study.

The project was approved officially for a research study at Oregon State College, beginning March 1, 1956.

The work form adopted consisted of one sheet (appendix figure 1). These were made up in a book form with four copies. One served as a job order form and could be given to the customer, another for billing the customer when the job was done, the third as a permanent record for the applicator's files, and a fourth copy to be sent to the college for computation and study. The form when completed, contained the order, execution, and amount charged. Crop treated, pest, chemical, application rate, method used, and charges for both chemical and application were some of the major items included.

All information for this study is based on data taken from copies of daily worksheets sent to Oregon State College for summarization by cooperating custom applicators. Each cooperator was given a confidential summary of his own operations at year's end.


ORDER No 21

Air ☐ Ground ☐

Crop

Pest
(Give name of insect, disease or weed)

Dusting ☐ Material
Spraying ☐ Furnished by:
Seeding ☐ Applicator ☐
Fertilizing ☐ Farmer ☐
(Refer to W. O. No.

Date Name Phone Map No. No. of Fields

Date Promised Address Strip Total Acres

DATE	PILOT OR OPERATOR	SHIP OR RIG NO	TIME A.M.	TIME P.M.	ACRES DONE	MATERIAL USED lbs. or No.	WIND DIR.	WIND VEL.	TEMP.	RATES PER ACRE CHEMICAL ACT. INGREDIENT	LBS.	OIL GAL.	H2O GAL.	WET. AGENT YES	WET. AGENT NO

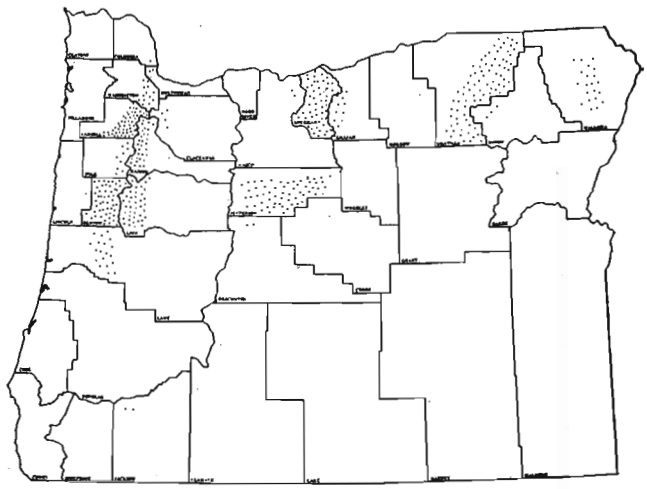
NORTH

APPLICATION: Date Acres @ $ per acre $

CHEMICAL: Brand Amount lbs. gal. @ $; Oil or Wet Agent gal. @ $

Signature TOTAL AMOUNT DUE $

Sample worksheet used by both "air" and "ground" chemical applicators.



Each dot represents 250 acres of chemical applications studied in 1956.