ECONOMIC ASPECTS OF CHEMICAL APPLICATION BY CUSTOM OPERATORS IN OREGON

by

MAURICE LUTHER JERNSTEDT

A THESIS

submitted to

OREGON STATE COLLEGE

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

June 1957

APPROVED:

Redacted for privacy

Professor of Agricultural Economics

In Charge of Major

Redacted for privacy

Head of Department of Agricultural Economics

Redacted for privacy

Chairman of School ~~Graduate~~ Committee

Redacted for privacy

Dean of Graduate School

Date thesis is presented April 20, 1957

Typed by Carol Anderson

ACKNOWLEDGEMENTS

The writer gratefully acknowledges the assistance given by Professor D. Curtis Mumford, Department of Agricultural Economics. His guidance, criticisms and suggestions throughout the whole study were most helpful. Also for the critical reading of the manuscript, the writer is very grateful to Dr. E. M. Castle of the same Department.

Valuable assistance and cooperation were obtained from various staff members of several departments at Oregon State College, and the State Department of Agriculture. Special recognition is due the chemical applicators who voluntarily cooperated by supplying the basic information for the study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ECONOMIC ASPECTS OF CHEMICAL APPLICATION BY CUSTOM OPERATORS IN OREGON

CHAPTER I

INTRODUCTION

Each year, American agriculture loses billions of dollars because of weeds, insects, and plant diseases. These pests seriously interfere with mans' efforts to grow useful plants. To combat this damage, the agricultural industry is turning more and more to the use of chemicals. Chemical applications are being made both by farmers themselves and also by custom operators. The latter is increasing rapidly, both by "ground" application and by "air" application of chemicals.

This thesis presents some of the economic aspects of this popular method of combating agricultural pests in Oregon through the employment of custom chemical applicators.

MAGNITUDE OF PEST DAMAGE

The full extent of the pest damage to plants, because of its nature, can only be estimated; yet even conservative estimates result in a staggering total of from ten to twelve billion dollars each year. This is highly significant when it is compared with the 1955 total gross income of farmers which is quoted as 33.2 billion dollars

(15, p.3). Were it not for the various control measures now being taken, the very existence of our intensive type agriculture would be seriously threatened, if not completely crippled.

Pest damage has increased in geometric proportions with the increased intensification of farming. When farms or farm communities were few and quite scattered, it was more difficult for pests to spread from one area to another. In the case of insects and disease, the host plants existed only in limited areas, so the spread was slow. Weed seed could not always compete effectively with the natural plant associations in an undisturbed or climax condition, so their distribution was limited by the natural wilderness that surrounded the early cultivated areas. As populations increased, more land was put into production. In many places, vast acreages were planted to the same crop, which created an ideal environment for many of the crop pests, and they spread rapidly throughout the entire area. Until the turn of the century, pests of one type or another were often the major limiting factor in the production of specific crops in a given area.

In order to understand more fully the seriousness of the damage done by pests, it is necessary to consider separately the three major groups of pests, namely weeds, insects, and plant diseases.

Weeds

Farm losses from weeds are much higher than is generally recognized. The Chamber of Commerce of the United States estimated in 1930 that the average farmer in the country lost at least 450 dollars per year because of weed damage (3, p. 4). We have fewer farmers today and therefore the individual farm cost would be much larger. Recent estimates indicate this loss nationally to be about five billion dollars a year (1, p. 23). Every area in the United States, used for agricultural purposes, has weed problems of one kind or another. Oregon is no exception.

In 1948, in order to ascertain an approximate annual cost of weeds in Oregon, a letter from the College was sent to the thirty-six County Agents in the State asking for the best estimate of weed losses in their respective counties. Twenty-one replies were received and the total loss figure for those reporting counties approached seven million dollars. Assuming this figure to be fairly close to the actual loss in the twenty-one counties, the loss for the thirty-six Oregon counties in 1948 might have been nearly eleven million dollars (6, p. 914).

The general consensus of opinion was that these figures represented a conservative estimate. A survey of the United States Chamber of Commerce in 1937 put the total weed loss in this country at between ten and fifteen per cent of the total agricultural income from crops at that time. If these percentages are representative of the present time and are applied to Oregon, we would find the loss due to weeds more in the order of forty to fifty million dollars a year, rather than eleven million.

One of the more serious results of weed infestation is their competition with crops for water, light, and mineral nutrients. Some of the other major losses could be summarized as follows: weeds contaminate agricultural products; harbor insects and disease; cause additional expense to the farmer in his efforts to control them; and jeopardize human and animal health through allergies, hay fever, asthma and internal poisoning causing sickness and death. In addition to the above, when farm land becomes badly contaminated with weeds, its capital value may be greatly reduced, thus making it difficult to get credit or to sell the farm.

Insects

Losses caused by all insects in the United States add up to an alarming amount whether regarded in terms of dollars, lost food and fiber, or time and materials used in combating them. That amount, in the opinion of entomologists, is at least four billion dollars for an average year (8, pp. 141-147).

Every minute of the day and night billions of insects are chewing, sucking, biting, and boring away at our crops, livestock, timber, gardens, homes, mills, warehouses, and ourselves. The amount of damage they do is difficult to evaluate. Many variable and complicating factors are involved. Even the damage by a specific insect to a specific crop differs from year to year, and from one area to another.

Insects cause losses in many different ways. Infestations reduce the yield of crops, lower their quality and saleability, increase the cost of production and of harvesting, and require outlays for materials, and equipment to apply control measures. Special equipment and work are required to remove effects of insects and of spray residues from edible materials, or else those contaminated products must be sorted out. Insects carry and spread plant, animal, and human diseases. They cause both direct and indirect losses in timber and its products. Insect-killed trees reduce protection in water shed areas, thereby exposing the areas to the danger of erosion; they become fire hazards and in many ways detract from the appearance of the land especially when it is used for recreation purposes.

Because of changes in the damage done by insects from year to year and place to place, there are no accurate figures as to the amount of damage done each year in Oregon. Assuming that insect damage in this state is relatively as important as it is nationally, the loss for Oregon might be estimated at approximately forty million dollars. This sum was derived by dividing the national insect loss (four billion dollars) by the national weed loss (five billion dollars) and determining that the insect loss was 80 per cent of the weed loss. Assuming Oregon to be comparable to the nation in proportion of pest losses, if there is an estimated 50 million dollar weed loss in Oregon, 80 per cent of that figure (40 million dollars) would represent the insect loss.

Plant Diseases

In the United States, the average annual loss from plant diseases is estimated to be about three billion dollars. Here again we have no way of establishing a precise figure, and this one is based on many assumptions. It could be well under, rather than over, the actual amount (17, pp. 1-10). Without the control measures now in use, the loss would be much greater.

The seriousness of plant disease, however, is not limited to the economic loss of the plant itself. Losses cannot always be measured in terms of dollars and cents. Plants manufacture the basic materials of life. The very existance of animals and human beings depends on the products of these living factories.

The losses from disease are directly attributed to the lowered efficiency or final breakdown in the plant's function. Disease then will reduce the yield and the quality of the product for which we grow the plant. Wilting, dieback, stunting, blighted or decayed produce, or a deformed product all represent losses to the farmer from disease. Control procedures and material costs plus increased handling costs to sort out the contaminated product must also be included. The loss from all diseases of all crops is estimated to be about ten per cent of the total crop production. That is an average; some crops suffer more from crop diseases than others.

In 1955 the total gross income in Oregon from crops was 230,352,000 dollars (16, pp. 44-45). If the ten per cent national loss figures are representative of Oregon, Oregon's loss would be about 26 million dollars annually due to plant diseases. This does not count the indirect losses to the livestock industry as a result of damaged crops and reduced forage production. If diseases had not affected the crops the income might have been approximately 256 million dollars.

An essential feature of all these losses caused by the various pests, is that they deprive everybody, not just the farmers, of the products destroyed. The damage and actual loss from pests in the United States is largely overshadowed by our present vast surpluses of agricultural products, and therefore it is difficult to interest the nation as a whole in this potential threat to its food supply. Individual farmers, however, are vitally concerned because the difference between the controlled pest and the uncontrolled one is what may give him his margin of profit or even keep him in business. The progressive farmer now realizes that pest control has become a necessary part of his farm management.

DEVELOPMENT OF CHEMICAL CONTROL MEASURES

Historically, pest control has probably been practiced since the dawn of agriculture. Early attempts at crop production must have been associated with weeding, first perhaps by pulling, and later by hoeing and cultivation. Crop rotations and manipulations of planting dates were practiced in trying to control weeds, insects, and plant diseases.

Chemical applications to control pests developed very slowly at first. As far as we know, common salt was the first chemical used to control weeds. For many centuries little or no work was done in producing effective chemical controls. The actual start of chemical control as we know it came in 1850 with the advent of carbon bisulphide which, if injected into the soil, would kill certain weedy plants. In the years following, several basic chemicals such as copper solutions, lime, lead arsenic, and sodium chlorate gradually came into use to control weeds, insects, and plant diseases.

The late 1930's and early 40's marked a great milestone in the battle with agricultural pests. The development in 1938 of sinox, a selective weed killer, gave new impetus to the field. During the second world war, extensive experiments on chemicals such as 2,4-D and DDT were carried on with marked success. Even though the government was looking for things primarily from a military standpoint, the usefulness of such chemicals for agricultural purposes could not be overlooked. From 1945 to the present, unprecedented strides have been made in pest control work.

As new and more complicated pesticide formulations were developed, the need arose for new and more adequate means to apply them. Methods of application have undergone continuous change since the first sprayers appeared in the latter part of the 19th century. Farmers speedily dropped hand application methods and turned to improved equipment for applying pesticides. Principal developments included high pressure sprayers for tree fruits and nuts, low pressure or low gallonage sprayers and mechanical dusters adapted primarily to field crops, and the increased use of airplanes for spraying and dusting. Attempts were made as early as 1918 to control insects by dumping poison dust from airplanes while flying over crops. By 1921 specially equipped airplanes had demonstrated their effectiveness for control of specific insect infestations. The airplane has become such a useful tool in combating pests that by 1952 more than five thousand were equipped for that purpose and many more are being added each year (9, p. 252).

In view of the foregoing discussion, the importance of pesticide control work should be self-evident. The very rapid development and use of these chemicals by farmers and commercial applicators points this out clearly. Newer and more effective pesticides continually come into use. With these new developments, acreages of farm crops and farm land treated for pests have expanded markedly. Purchases of power sprayers and dusters in recent years have been more than six times the average annual purchases of the prior period (2, p. 1).

In an effort to learn the extent and cost of spraying and dusting for control of crop insects and diseases and for control of weeds and brush on farms, the Department of Agriculture sent a questionaire to 23,500 voluntary crop correspondents in all parts of the United States. In reporting on the control of weeds and brush, these crop correspondents supplied data concerning acreages of corn and principal small grains seeded on their farms for 1952 harvest. Included, also, was the acreage of pasture land, and "all other crops and land" treated with herbicides. They reported acreages treated with their own equipment and by custom operators in 1952. Information as to the number of times each crop or land use was treated, total cost of the herbicides applied with their own, borrowed, or exchanged equipment, and amounts paid to custom operators were also reported. The same type of data was obtained for the control of insects and diseases on various other types of crops.

It should be remembered that these results are estimates extrapolated from a small sample and that the figures are averages for fairly wide areas. Some modifications from sample indications were made after consultation with specialists in different states. The data in Table I indicates the total acreages of all farm crops and farm land sprayed or dusted for weeds, insects, and diseases in 1952.

These data show that in 1952, sixty million acres were treated at least once for pest control in the United States. In the Pacific Coast States substantially more than half of the spraying and dusting was done by custom operators while in other regions most of the work was done with the farmers' own equipment. In 1952, of the total United States acreages sprayed or dusted, about seventy per cent was treated by farmers and thirty per cent by custom operators.

Acreage gives only one indication of the extent of chemical work done. Another very meaningful measure is

Table 1. All farm crops and farmland: Acreage sprayed or dusted for control of weeds and brush and for insects and diseases, by area, 1952.*

Area	Acreage treated	Times treated	Acreage treated-once over basis By farmer	Acreage treated-once over basis Custom applicators
	1,000 acres	Number	1,000 acres	1,000 acres
		Weeds and brush		
Pacific States	4,668	1.19	2,740	2,796
United States	31,101	1.08	22,890	10,660
		Insects and disease		
Pacific States	4,530	2.35	4,393	6,234
United States	29,002	2.86	59,114	23,886
		Total spray and dust done		
Pacific States	9,198	1.77	7,133	9,030
United States	60,103	1.94	82.004	34,546

* Extracted from USDA Statistical Bulletin No. 156, April 1955, Table 1, pp 4.

its cost stated in dollars and cents. Table II shows, for each of the Pacific Coast States, a breakdown of spraying and dusting costs for specific purposes. It also shows a comparison of the costs of control measures on the West Coast with those of the United States.

Farmers in the United States are estimated to have expended over 132 million dollars for pesticide materials they applied in 1952 with their own equipment. This figure does not include costs of application and labor. In addition, farmers paid custom operators about 109 million dollars for spraying and dusting crops, and other lands. Thus the total cost of materials applied with the farmers' own equipment, plus charges of custom operators, was about 241 million dollars. If the value of the farmers' own time, and equipment is added to this figure, it is estimated that the total cost of all the chemical pest control work done in the United States in 1952 by both the farmers themselves and custom operators, was about 363 million dollars.[1]

There are no total figures available for an estimate of the increased income per dollar of control costs, yet it is obvious farmers believed the figure would have to be equal to or greater than the cost. Figures on grasshopper control indicate that the estimated value of crops

---

1 It is assumed that 109 million dollars worth of commercial pesticide work done in 1952 was approximately thirty per cent of the total.

Table 2. Cost of spraying and dusting, specified purposes, by states, 1952.*

Area	Cost of material applied by farmers			Cost of materials and their application by custom workers		
	Weed control	Insect & disease	Total	Weed control	Insect & disease	Total
	1,000 dollars	1,000 dollars	1,000 dollars	1,000 dollars	1,000 dollars	1,000 dollars
Washington	936	2,008	2,944	1,445	2,891	4,336
Oregon	784	2,307	3,091	1,333	1,249	2,582
California	4,737	10,810	15,547	4,205	29,615	33,820
Pacific States	6,457	15,125	21,582	6,983	33,755	40,738
United States	25,848	106,593	132,441	21,947	86,851	108,798

* Extracted from USDA Statistical Bulletin No. 156, April 1955, Table 1, PP. 5.

saved by control measures in a sixteen year period (1934-1950) ranged from about 5½ million to about 176 million dollars for the one pest (8, p. 142). On the basis of these data it is estimated control measures for weeds, diseases, and insects must save agriculture a sum in the billions of dollars each year.

How this Study Developed

Interest in a research program to study commercial chemical applications in this state started several years ago. In Oregon certain restrictions placed on custom operators, were one of the factors making possible the present study. Because of the types of materials used and their various effects on plant and insect life, great care must be taken to use these chemicals properly. Two general statements can be made in summarizing the Oregon Herbicide Applicator law (10, p.5):

1. The custom applicator operating a business is required by law to have a license, to register equipment, and to hire only licensed applicators.
2. It is the responsibility of each applicator to be sure his license is in good standing before he makes any application of herbicides.

In addition to the herbicide law, there are other restrictions placed on custom operators. Aerial operators must meet certain requirements concerning registration and operation. These are restrictions concerning toxicity and public health aspects of pesticides, and Oregon has an economic poison law requiring all chemical materials sold as pesticides to be properly labeled and directions given for their use. The last two laws mentioned above are summarized more fully in the appendix under titles of: "Oregon Economic Poison Law"; and "The Miller Amendment".

The State Department of Agriculture has the responsibility of licensing custom operators. To qualify, the operator is required to take a written examination which includes questions about characteristics of pesticides and their effects on crops; methods of application; conditions, timing and precautions in using the various chemicals; and the laws, rules and regulations on pesticide applications.

To help the individual become familar with this information and to present any new material of interest and value, the State Department of Agriculture, in co-operation with Oregon State College, sponsors a short course for all of the chemical applicators doing custom work in Oregon. In 1953, the planning committee for the Third Annual Oregon Agricultural Chemical Applicators' Short Course discussed the need for an economic study on chemical applications. Such a study, it was said might tend to tone down the criticism of drift damage, show in dollars and cents the net benefit per acre of chemical applications, add to present knowledge of effectiveness of chemical applications, and might provide solid facts for sound proposals by legislative committees.

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

In the later stages of development the college received the active cooperation of several representatives of the air and ground applicators, and the final form was approved by them and by representatives of the State Department of Agriculture before it was printed. The project was then approved officially for a research study at Oregon State College to begin on March 1, 1956.

The work form adopted consisted of one sheet. There were four copies. One copy was used as a job order form, another copy for billing the customer, one for a permanent job record for the applicator's files and future reference, and a fourth copy was for the purpose of sending the information to the college for computation and study. The form, when completed properly, contains a complete picture of the job. Crop treated, pest, chemical and its application rates and methods used, and the charges for both the chemical and the application itself were some of the major items included. An actual work form is included in the appendix. From the information provided on these forms sent in voluntarily by a number of the commercial applicators, both ground and air, the study was made.

Objectives of the Chemical Study

The objectives of this study on economic aspects of chemical application by custom operators in Oregon were as follows:

1. To determine the extent of chemical applications (pest control and fertilizer) in Oregon by operators (both ground and air) engaged for hire.
2. To determine the total amount and kinds of chemicals applied, including rates per acre, to what applied, and for what purposes.
3. To determine the method of application (spray or dust) and the important circumstances surrounding each application, such as wind velocity, temperature, month of application, size of jobs, and

number of fields.

4. To determine the commercial charges for all "custom work jobs".

CHAPTER II

METHODOLOGY AND DESCRIPTION OF STUDY AREA

The first step in this project was to develop a practical worksheet for the use of chemical applicators that would; (1) contain the necessary information for their own records, (2) give the farmer clients a specific record of what was ordered, and (3) provide the college with the detailed data necessary for this study. This development was explained in the introduction.

A second necessary step was to obtain and compile lists of pests, chemicals, and crops that are of importance in Oregon. Three major groups of pests were to be considered; weeds, insects, and diseases, as they apply to crops, and other land use in the State.

The list of weeds was developed in close cooperation with the Farm Crops Department at Oregon State College. The plants included represented major problems as weeds in some area or areas of the State. The list was then alphabetized, and each weed given a code number of its own. As the study progressed, other weeds, on which commercial work was done, were added to give as complete a picture of the actual herbicide work done in Oregon as possible.

The College Entomology Department was the main source of information in compiling the list of insects. The list was formulated by putting the insects into main families such as beetles or mites, and then including all those specific varieties of consequence under the proper heading. The listing was then put in alphabetical order, and each species given a code number.

Diseases were first listed and then coded under two main groups, the fungi and the nematodes. The Department of Botany and Plant Pathology at Oregon State College was the main source of this information.

The determination of the crops and land used to include in the study presented some problems. Each category had to be specific enough to accurately indicate what was being done, yet general enough to include those crops or land uses that were not specifically named by type or variety. Cherries offer an excellent example of this. Many times the variety was not listed and no designation as to sweet or sour cherries was indicated. Since the treatment was essentially the same for all types of cherries, they were grouped and coded under the one heading, "cherries".

The chemicals used as pesticides on agricultural lands are many and varied. Not only are single chemicals used but also many combinations of them. In this study, primary concern has been given to single chemical applications, so in the coding process these single compounds were alphabetically listed, using both the common or trade names, and their chemical designation whenever possible.

Provision was made, however, to include combinations of two, three, and four chemicals in the tabulation of the final data. Several professional publications were consulted and help was obtained from the Agricultural Chemistry Department at Oregon State College. Chemicals in the form of fertilizers were arranged and coded separately according to the name of the fertilizer and not considered as specific chemicals. They were classed as a separate type of operation. This list was obtained from the Soils Department of the College.

When compiling the classifications of pests, just as was done in crops, an all inclusive category was added where ever possible in order to include varieties of pests not specifically named. For example, some of the incoming work forms listed the pests merely as "weeds" or "grass". Code numbers were set up for both of these classifications but after discussing this problem with the interested departments at the college, it was generally agreed that their use would increase the value and extent of the sample sufficiently to justify such procedure. This occassional grouping of pests on the part of commercial applicators, while not extensive, may point out a difficulty of identifying specific species of pests. This was particularily evident in the weed results.

Commencing early in the spring of 1956, nineteen commercial applicators--nine "air" men and ten "ground" men, began keeping the proposed worksheet in order to participate in the study. Approximately once a month, each cooperating applicator, sent one copy of the completed worksheet for each job to the Department of Agricultural Economics for summarization and analysis. Each of these jobs or worksheets was then edited, coded, and tabulated. Periodically this information was punched on IBM cards. These cards were allowed to accumulate until the end of the year when summary analyses were run.

During the entire year the Departments of Farm Crops, Horticulture, Soils, Entomology, Botany and Plant Pathology, and Agricultural Chemistry, including their extension specialists, were of considerable help in answering many questions concerning the information contained on the worksheet. The State Department of Agriculture, at Salem, supplied a list of all licensed herbicide applicators in Oregon, and cooperated in every way in encouraging participation in the study.

MAGNITUDE OF THE PRESENT STUDY

There are three ways of indicating the size of this study. It can be measured in terms of total acres, total jobs, and the total charges made for the work done (see Table 3). Ground and air applications were summarized separately in an attempt to evaluate each of the methods as a means of economic pest control, and so that results

Table 3. Summary of the work done in the chemical application study: Number of jobs, total acres, average acreage per job, charge per acre and total application charges for both ground and air by type of operation.

Type of operation	No. of jobs	Total acres	Acres per job	Charge* per acre	Total appli.* charges
		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	1573	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	1514	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
Total	2252	108,549	48.2	$ 1.56	$168,978

* Application charge does not include chemical charges.

of one or the other, would not influence unduely, the final analysis.

As indicated in Table 3, a total of 108,549 acres were included in this study. Of this total, air applications contributed 97,148 acres or about ninety per cent of the acreage, but only seventy per cent of the jobs. This is because the average size of the air jobs was 61.7 acres compared to 16.8 acres for ground jobs. This extreme difference in the size of jobs between "air" and "ground" is quite important and as will be shown later, the size of jobs done by the two groups has undoubtedly affected the per acre charges for application. As a general rule, the smaller the job, the higher the charges. This is illustrated by the difference in the average charge per acre at $2.04 for ground work as compared to $1.50 for air.

For both ground and air, spraying was much more important than dusting. In this connection it is perhaps significant that the charges for spray applications per acre were substantially lower than for dust. Fertilizing, seeding and combinations of various operations represented only a small portion of the total sample. The per acre charges for these were slightly higher than spraying, yet considerably less than for dusting.

DETERMINING THE RESPRESENTATIVENESS OF THE SAMPLE

To determine the representativeness of the sample, it was first necessary to obtain an estimate of the total amount of commercial pesticide work done in Oregon. This was done through cooperation with the State Department of Agriculture. At the suggestion of the College, the State Department sent a questionaire to each licensed herbicide applicator operating in this State. These applicators were asked to estimate the acreage of commercial work done by them in 1956, and to separate the three application operations of spraying, dusting and fertilizing. Many of the licensed applicators were employees of other individuals or companies. To avoid duplication of acreage reports, the survey was so worded as to indicate the relation of each to a commercial business. The breakdown was for four groups. They were owner-applicator, partnerships, managers of businesses, and employees. In this way accurate estimates of the work done by commercial chemical businesses were obtained without duplications. The results of the State Departments' survey are shown in Table 4.

Because the response of the applicators was not one hundred per cent, even after second and third reminders, the State Department of Agriculture estimated the acreage done by those applicators who did not reply. The Division

Table 4. Estimated total acres of commercial chemical applications by licensed herbicide operators in Oregon, in 1956, compared to the acreage included in this study.

Type of operation	State Department of Agriculture survey (acres)	Corrected State Department estimate (acres)	OSC study (acres)	Per cent of the total acreage in OSC study
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%

of Plant Industry, State Department of Agriculture, through its supervisor in charge of the licensing of herbicide applicators has very close contact with their work and was in a good position to estimate acreages of commercial work done by them. Column three in Table 4 indicates the connected estimates of the total acreage treated by herbicide licensed operators in Oregon. Although these figures are estimated, they represent the best data available for 1956. From the data in Table 4, it would appear that the present study includes about 19 per cent of the total dusting work done, and about 33 per cent of the total fertilizer applications. Of the 573,574 acres commercially treated in Oregon in 1956, 108,549 acres or approximately 19 per cent were included in the sample. Actual chemical work, as it is considered here, consisting of the sum of all spray and dust operations, constitutes a 17 per cent sample.

AGRICULTURAL AREAS SAMPLES IN OREGON

The commercial chemical sample was obtained in several different areas of the State as is shown in Figure 1. Each dot represents 250 acres or some part thereof. Acreage was used, rather than the number of jobs, because of the wide variation in job sizes from one area to another.

Twenty of Oregon's thirty six counties are

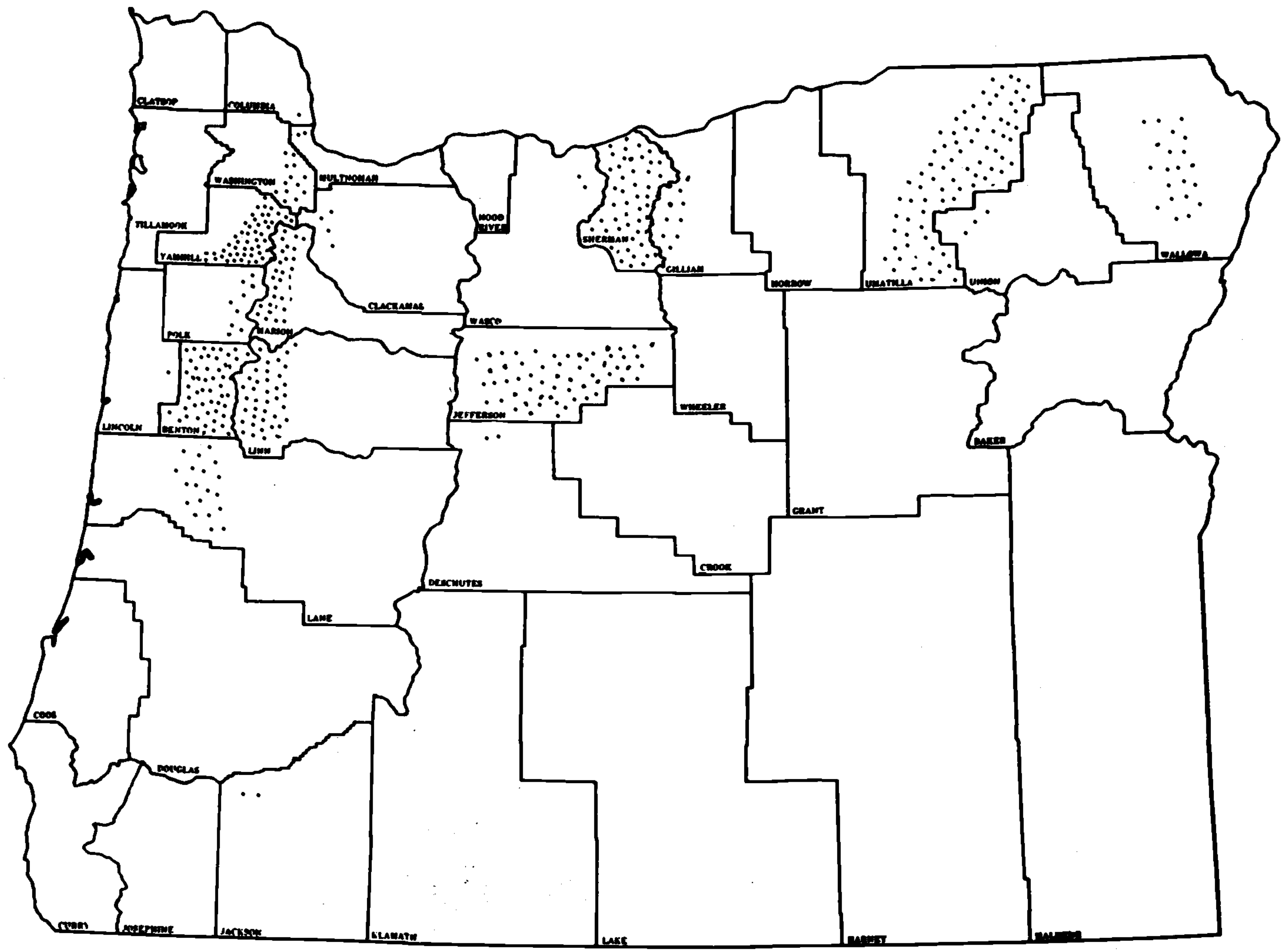

Figure 1. Distribution of commercial applications in Oregon. Each dot equals two hundred and fifty acres or some part thereof.

represented in the chemical application study data. Total acreages treated in the various counties ranged from a low of sixty acres in Lincoln, to a high of nearly nineteen thousand acres in Umatilla County. Major agricultural areas represented in the study were the Willamette Valley, Columbia Basin, Central Oregon Counties, and the Snake River Basin. These widely separated agricultural areas of the State are subject to very different environmental influences, and are adapted to quite dis-similar types of farming. The results obtained in this study show the effects of a changing environment, and type of agriculture on the demand and use of chemicals for pest control. The four major areas covered in the study are briefly described below.

Willamette Valley

The Willamette Valley, running north and south in the State, lies between the Cascade mountains on the east, and the Coast Range of mountains on the west. It is a combination of green valleys and timbered hills. The soil is very productive, the climate mild, the growing season long, and as a result, agriculture is diversified. Intensified and speciality crops are important. Major crops are fruit and nuts, vegetables, and grass and legume seed crops. Most of the commercial work in the valley was done in Yamhill, Marian, Linn and Benton counties.

The work done by these four comprised one third of the total sample.

As indicated previously, this study of commercial application of chemicals includes treatments to control insects, weeds, and plant diseases. Table 5 presents a breakdown of all custom work done in each county by the type of pest treated.

Several interesting facts become apparent when considering the data in this Table. Two of the counties, Benton and Linn were almost entirely serviced from the air, while Yamhill and Marian counties received a substantial amount of both air and ground applications. Due to the intensive type of farming, the Willamette Valley counties had the smallest job size average of any of the areas included in the sample. Another interesting feature was that most of the disease control treatments reported took place in the Valley. Probably this was because intensive or speciality crops are subject to a larger variety of diseases.

Columbia Basin

The Columbia Basin runs east and west and is adjacent to the Columbia River in the extreme north central part of the State. The area consists almost entirely of dry land farming and range cattle production. Wheat and peas are the major crops. Umatilla led all other counties in acreage treated with nearly 19,000 acres. Sherman County was second with 12,000 acres of mostly herbicide work. Commercial chemical applications made by air for weed control are extremely important in the dry land farming areas because weeds compete directly with crops for moisture.

Snake River

The Snake River Basin is located in the northeast corner of the State with the Snake River forming its eastern boundary. The area receives limited rainfall, and is subject to freezing weather any month. Agriculture is of the extensive type with livestock production, alfalfa, and wheat the major enterprises. Most of the work in this area was for weed control. Herbicide application to wheat in Wallowa County was most important.

Central Oregon

The Central Oregon Counties lie just south of the Columbia Basin in the central section of Oregon. This area has a hot, dry climate during the growing season, and is subject to extremely cold temperatures in winter. Dry-land farming and ranching are intersperced with irrigation projects. Within these projects, ladino, red and alsike clover seed production, alfalfa and potatoes are the important crops. Wheat and livestock production predominate in the dryland areas. All of the chemical work was done by air.

SUMMARY OF COUNTY WORK

Weed Control

Chemical weed control constituted 90 per cent of the ground and 54 per cent of the commercial air applications included in this study. Counties receiving the greatest amount of herbicide treatments were Sherman, Umatilla, Jefferson, Yamhill, and Wallowa. These five counties represent four of the major agricultural areas of the State, namely, the Columbia Basin, Central Oregon, Willamette Valley, and the Snake River Basin. Because of this, nearly every condition and environment was represented in the data.

Most weed control applications represented spray work, but there was a small acreage treated for soil sterilization purposes using a granular formulation rather than some other form of application (see appendix for formulation types). The main reason for spraying is the method of chemical absorbtion by the plant. This will be explained when considering factors influencing the effectiveness of chemical applications.

Table 5. Summary by county: Total acres treated in each pest class by the type of operation done and by ground and air application.

County	Operation	No. of jobs	Total acres	Air application, acres				Ground application, acres			
				No. of jobs	Insects	Weeds	Diseases	No. of jobs	Insects	Weeds	Diseases
Benton	Dusting	13	301	13	291		10				
	Spraying	197	8,615	196	4,409	3,997	207	1		2	
	Fertilizing	50	3,309								
	Other	12	393			82					
	Total	272	12,618	210	4,700	4,079	217	1		2	
Clackamas	Dusting	2	18	1	15			1	3		
	Spraying	48	716					48	34	682	
	Fertilizing	13	92								
	Total	63	826	1	15			49	37	682	
Columbia	Spraying	11	56					11	33	23	
Deschutes	Spraying	3	381	3		381					
Gilliam	Fertilizing	2	2,140								
Jackson	Dusting	2	8					2		8	
	Spraying	52	359					52	17	342	
	Total	54	367					54	17	350	
Jefferson	Dusting	17	443	17	443						
	Spraying	281	13,192	281	7,634	5,376	182				
	Fertilizing	30	935								
	Total	328	14,570	298	8,077	5,376	182				

Table 5. (cont.)

County	Operation	Total application		Air application, acres				Ground application, acres			
		No. of jobs	Total acres	No. of jobs	Insects	Weeds	Diseases	No. of jobs	Insects	Weeds	Diseases
Lane	Dusting	13	205	13	195		10				
	Spraying	98	3,560	98	2,821	474	264				
	Fertilizing	12	847								
	Other	1	30								
	Total	124	4,642	111	3,016	474	274				
Lincoln	Other	1	60								
Linn	Dusting	14	330	14	322		8				
	Spraying	73	3,186	69	1,020	2,080		4		85	
	Fertilizing	78	6,186								
	Other	4	120								
	Total	169	9,822	83	1,342	2,080	8	4		85	
Marian	Dusting	81	4,482	81	3,981		501				
	Spraying	79	1,904	17	232	316		62	42	1,315	
	Fertilizing	17	945								
	Other	1	115								
	Total	178	7,446	98	4,213	316	501	62	42	1,315	
Multnomah	Dusting	9	118	5	101			4	17		
	Spraying	40	318					40		318	
	Fertilizing	2	18								
	Total	51	454	5	101			44	17	318	
Polk	Dusting	5	85	5	75		10				
	Spraying	22	1,237	17	928	150		5		158	
	Fertilizing	11	701								
	Total	38	2,023	22	1,003	150	10	5		158	

Table 5. (cont.)

County	Operation	Total application: No. of jobs	Total application: Total acres	Air application, acres: No. of jobs	Air: Insects	Air: Weeds	Air: Diseases	Ground application, acres: No. of jobs	Ground: Insects	Ground: Weeds	Ground: Diseases
Sherman	Spraying	58	11,801	58		11,801					
	Fertilizing	3	228								
	Total	61	12,029	58		11,801					
Umatilla	Dusting	75	1,400	75	1,280						
	Spraying	94	11,517	94	1,187	10,330					
	Fertilizing	17	5,936								
	Other	1	120								
	Total	188	18,973	169	2,467	10,330					
Union	Dusting	1	78	1			78				
	Spraying	1	430	1		430					
	Total	2	508	2		430	78				
Wallowa	Spraying	78	5,003	78	481	4,522					
Washington	Dusting	66	850	13	342		214	53	258		36
	Spraying	142	2,245	2		48			164	2,033	
	Fertilizing	2	6								
	Total	210	3,101	15	342	48	214	193	422	2,033	36
Wasco	Spraying	1	300	1		300					

Table 5. (cont.)

County	Operation	Total application		Air application, acres				Ground application, acres			
		No. of jobs	Total acres	No. of jobs	Insects	Weeds	Diseases	No. of jobs	Insects	Weeds	Diseases
Yamhill	Dusting	170	6,751	169	5,953		788	1	10		
	Spraying	229	5,322	11	547	92		218	74	4,609	
	Fertilizing	8	581								
	Other	3	110					1			
	Total	410	12,754	180	6,500	92	788	220	84	4,619	
State of Oregon*											
	Grand Total	2,244	108,073	1,334	32,259	40,378	2,271	643	653	9,585	36

* Eight jobs including 476 acres done in Washington State are not included in the county summary.

Insect Control

Application of chemicals for insect control comprised the other major segment of the chemical data. Thirty three thousand acres of crops or land uses were treated for various insect pests. All but 650 acres was covered by "air". Furthermore, fourteen of the twenty counties were represented. Jefferson, Yamhill, Benton, Marion and Lane counties had the greatest acreage treated. Of the five, four were in the Willamette Valley, the other being in the Madras irrigation project of Jefferson County in Central Oregon. This indicates that in areas growing fruits, nuts, vegetables and various seed crops, insect control is more necessary than for enterprises as grain and livestock production. In other words, fruits and vegetables are more subject to insect damage than is wheat.

Disease Control

Chemical application for the control of plant diseases was a very minor portion of the study. The "disease" sample contained 2,307 acres or only about three per cent of all the chemical work done. Leading counties were Yamhill, Marion, Lane, Washington and Benton, all of which are in the Willamette Valley. Only nine of the twenty counties had applications for this type of pest. All disease treatments were done by air except in Washington County where both ground and air applications were made. Three fourths of the disease control treatments were in the form of dust, the remainder being applied as a spray.

Fertilizer and Other Work

While not actually part of the chemical study, fertilizer and "other" work contributed 268 jobs and 22,901 acres or 20 per cent of the total sample of commercial work done in Oregon. This indicates the importance of this type of work to the commercial applicator. Leading counties were Linn, Umatilla, Benton, and Gilliam. Both Willamette Valley and Eastern Oregon dryland farming areas were represented. Nearly all of the fertilizer jobs were done from the air in a dust or granulated form. Thirteen counties were reported as having some fertilizer work done.

"Other work" consisted of seeding or combinations of two jobs done at the same time. Examples are fertilizing and dusting, or fertilizing and seeding. Only five counties had work of this kind and the acreage was of little consequence in relation to the total study.

CHAPTER III

CROPS AND LAND USES INCLUDED IN THE CHEMICAL STUDY

Oregon produces a great variety of crops under many different environmental conditions. There are semi-deserts in Eastern Oregon with their sharp temperature variations and short growing seasons and at the other extreme there is the coastal region with its very high rainfall and long growing season. In between lies a fertile valley with a moderate temperature and long growing season. Each has crops that are well adapted to its peculiar conditions. Every crop has at least one pest, and probably many, which can lower its production and reduce the quality of the product. To meet this problem, farmers are turning to chemicals for pest control. One of the purposes of this study was to find out which crops are being treated chemically and for what pests.

The crop code list prepared for the chemical study consisted of 84 categories showing specifically, the major agricultural crops, and showing, in groups, the crops of lesser importance. In addition, the major land uses were also listed. The entire crop and land use code list is included in the appendix. In the study sample, 54 of the 84 categories were represented as receiving some type of commercial treatment.

In this chapter all those crops or land uses on which custom work was done will be considered by the type of operation performed. The breakdown includes dusting, spraying, fertilizing and "other". In addition to a general presentation of all commercial work done, ten representative crops of different types have been selected for individual summary of the actual pests for which chemical controls were applied. For these selected crops, the economic feasibility of control measures will be shown by determining the amount of increased production needed to pay for the chemical and its application.

CONSIDERATION OF CROPS AND LAND USE BY TYPES OF OPERATION

This discussion will be presented in the following order. The first operation to be considered will be dusting, followed by spraying, fertilizing and "other." As a further breakdown, air and ground applications will be kept separate. This information will be summarized first by selecting and discussing the more important crops or land uses to which applications were made. This will be followed by a presentation and comparison of all the dusting work done.

In like manner the spraying operation will be considered, followed by a short discussion of "fertilizing" and "other".

Dusting From The Air

Aerial applications of dusts contributed 14,736 acres or about 87 per cent of the total dusting work. A total of 408 jobs were done on thirty different crops or land uses. These applications were almost entirely for insect and disease control. Thos crops receiving the greatest amount of custom work are listed in Table 6.

Table 6. Summary of the leading crops dusted by air: Number of jobs, total acres, average job size, and average per acre application charges.*

Crop or land use	No. of jobs	Total acres	Ave. acres per job	Appli. char. per acre
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

* This data is extracted from Table 8.

Canning peas received the most custom applications having 3,590 acres chemically treated. Cabbage and cauliflower (Table 8) had the least, with six acres each. The three leading crops, canning peas, vetch, and field peas, all legumes, were treated for the same type of insect--the weevil. These three crops had half of the total acreage dusted by air.

The average size of job flown by the crop dusters was 36.1 acres. The range was from six acres to 202 acres. The application charge ranged from $1.47 per acre on onions to $5.00 for cabbage. For the entire aerial dusting work, $2.26 was the average application charge.

Dusting From The Ground

Very little dusting work was done with ground equipment. Sixty-two jobs were required to treat 347 acres. Sixty jobs were on tree fruits and nuts, the other two being listed under "other" uses. Filberts was the only crop on which any substantial work was done and its relative importance is shown in Table 7.

Table 7. Summary of important dust applications by ground rigs: Number of jobs, total acres, job size and average per acre application charges.*

Crop or land use	No. of jobs	Total acres	Ave. acres per job	Appli. char. per acre
Filberts	43	268	6.2	$ 1.77
All others	19	79	4.1	5.78
Total	62	347	5.6	$ 3.02

* This data is extracted from Table 8.

The average size of the dusting jobs done by ground operators was very small. For all the ground work done, the average size of job was 5.6 acres, ranging from 1.1 to 8.2 acres (Table 8). Charges for application averaged

$3.02, ranging from $1.67 to $54.62 per acre. In Table 7 it will be noted that the average application charge for "all others" was $5.78 per acre. This relatively high figure was influenced by the inclusion of such expensive "per acre" jobs as city lawns, school grounds, fence rows, right of ways, irrigation ditches, and so forth. Such jobs were classified as "other uses".

Air And Ground Dusting Operations Compared

It is almost impossible to make significant comparisons between dusting jobs done by air and ground applicators. This is true because as indicated in Table 8 very few crops were dusted to any extent by both means. Some comparisons can be made however on those crops that had work done by both. Table 8 presents comparative data for dusting jobs done on cherries, prunes and filberts by both air and ground operators.

It is significant to note that on the average, ground dusting application was cheaper. This is a complete reversal of the usual situation, and perhaps explains why most of the orchard work was done by ground operators.

Spraying

This study included 108,549 total acres of commercial work. Sixty-five per cent (70,603), comprising forty-five of the 54 different crops and land uses, were treated

Table 8. Summary of all chemical work done by crop and land use: Number of jobs, total acres, average acres per job and average application charge for ground and air dusting and spraying.

Crop or land use	Ground application				Air application			
	No. of jobs	Total acres	Ave. acres per job	Ave. appl. charge per acre	No. of jobs	Total acres	Ave. acres per job	Ave. appl. charge per acre
Dusting								
Alfalfa					4	354.0	88.5	2.12
Clover					6	98.0	16.3	1.50
Field peas					64	1459.5	22.8	1.91
Vetch					70	2132.0	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 speciality field and drug crops					1	40.0	40.0	2.50
Cherries	6	19.5	3.2	2.31	30	1015.5	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 and hazelnuts	43	268.5	6.2	1.77	7	126.0	18.0	2.37

Table 8. (cont.)

Crop or land use	Ground application: No. of jobs	Total acres	Ave. acres per job	Ave. appl. charge per acre	Air application: No. of jobs	Total acres	Ave. acres per job	Ave. appl. charge per acre
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	1875.0	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	3590.5	40.8	2.43
Potatoes					24	1505.5	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
Total	62	347.3	5.6	3.02	408	14,736.0	36.1	2.26

Table 8. (cont.)

Crop or land use	Ground application: No. of jobs	Ground application: Total acres	Ground application: Ave. acres per job	Ground application: Ave. appl. charge per acre	Air application: No. of jobs	Air application: Total acres	Air application: Ave. acres per job	Air application: Ave. appl. charge per acre
				Spraying				
Barley	55	902.6	16.4	1.25	29	2663.2	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	8	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	1814.6	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

Table 8. (cont.)

Crop or land use	Ground application: No. of jobs	Total acres	Ave. acres per job	Ave. appl. charge per acre	Air application: No. of jobs	Total acres	Ave. acres per job	Ave. appl. charge per acre
Idle land								
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
Cherries	1	12.0	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
Spinich	1	9.0	9.0	2.22				

Table 8. (cont.)

Crop or land use	Ground application: No. of jobs	Total acres	Ave. acres per job	Ave. appl. charge per acre	Air application: No. of jobs	Total acres	Ave. acres per job	Ave. appl. charge per acre
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
Total	587	10,272.8	17.5	1.99	927	60,330.3	65.1	1.33
Dust and Spray Total	640	10,620.1	16.5	2.02	1,335	75,066.3	56.2	1.51

with spray. Spraying 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 if application was made by the spraying operation. The average per acre charge for spray application was $1.42 as contrasted with the average dusting charge of $2.28 per acre. Chemicals are produced for pesticide work primarily in two forms. (a) as a dust, and (b) as a liquid concentrate or wettable powder to be used as a spray. When dusts are used, the concentrated chemical is mixed in a "carrier material" such as talc. The cost of the dust therefore includes not only the cost of the concentrate itself but also the cost of the talc. Still more important the transportation cost of all this material must be paid from the point of purchase. On the other hand, for spray purposes the concentrated chemical may be purchased without this additional expense since water can be added any time.

(2) Spray may be applied under a wider set of conditions. Dusts are much more volatile than sprays. Many times spraying can be done under conditions that would be too windy for dust.

(3) Sprays have a longer residual effect, a critical factor in controlling some pests.

<u>Aerial Application of Sprays</u>

Sprays from the air were applied to 34 different crops and land uses, covering sixty thousand acres in several parts of Oregon. Leading crops are shown in Table 9.

Table 9. Summary of leading crops treated by aerial application of sprays: Number of jobs, total acres, average size of job and average charge of application per acre.*

Major crops	No. of jobs	Total acres	Ave. acres per job	Ave. appli. charge**
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

* This data extracted from Table 8.
** Application charges do not include charges for chemical.

Wheat received more chemical application than any other single crop in the study. The aerial applications of spray to this crop constituted 24 per cent of the total acreage for the entire sample. Most of the wheat acreage was in Central and Eastern Oregon, as the large average job size would indicate. The other leading crops show a preponderance of legumes, namely vetch, field peas and clover.

The range in the size of job varied from seven to 194 acres. For all the custom spray work done by air the average size of job was 65.1 acres. The average charge for applying the chemicals was $1.33 per acre. Charges for specific crops varied depending on the crop or land use. The charge was $0.94 to treat alfalfa (Table 8), while for cranberries, it was $4.50 per acre.

Ground Application of Sprays

Spray applications, by ground rigs, were made on 34 different crops or land uses. Over ten thousand acres were covered in 587 jobs (Table 10). The majority of the ground work was done in the Willamette Valley where smaller acreages and intensified crop production allow ground men to compete more effectively with the commercial air men. The leading crops sprayed are entirely different from those sprayed by "air". This can be seen by comparing Tables 9 and 10.

In Table 10, the designation "other" grains includes all grains except barley, corn, oats, rye and wheat. In addition, when the applicators sent in worksheets which listed "grain" as a crop, but no designation as to the variety, it too was included in the "other" grain category. The term, "other" uses was explained in the section on dust applications. This type was usually quite small with several jobs being less than an acre.

Table 10. Summary of leading crops or land uses sprayed from the ground: Number of jobs, total acres, average job size and average application charge per acre.*

Major crops	No. of jobs	Total acres	Average job size	Average application charge**
"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

* This data extracted from Table 8.
** Application charges do not include charges for chemical.

The average size of job for the ground spraying work was 17.5 acres. The range was from 1.5 to 89.4 acres. The average application charge was $1.99 per acre. Walnuts were treated for an average of $1.09 per acre and the "other" uses charge was $5.54 an acre for application.

Ground and Air Spraying Compared

Ground and air spray applications can be compared by considering the crops that were treated by both methods. Table 8 is set up to show the same data for both "ground" and "air" on specific crops, and by method of application. The combined summary of all ground and air treatments done on all crops and land uses is presented in the appendix.

Nearly all the legume and grass spray work was done from the air, with the exception of clover treatments which were done by both methods. All the 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

The commercial application of fertilizers has become an important part of the overall business of many of the custom operators so is included in the chemical study. Since it is not a chemical in the same sense as are pesticides, a special section has been devoted to it. Fertilizer work has been summarized as to the crops on which it was used (Table 11).

Wheat and ryegrass received 80 per cent of the total fertilizer applications. This was done entirely by aerial methods. Strawberries was the major crop fertilized with ground equipment. The average charge per acre for ground fertilization was $2.43, the average size of job, 25.2 acres. For aerial fertilizing, the average charge was $1.46 an acre and the job size, 97.4 acres. It is perhaps significant that the charge for applying fertilizer was usually substantially less than for applying dusts, a similar type of work.

Table 11. Summary of all fertilizer and "other" work done by crop and land use: Number of jobs, total acres, average acres per job, and average application charge for ground and air applications.

Crop or land use	Ground application: No. of jobs	Ground application: Total acres	Ground application: Ave. acres per job	Ground application: Ave. appl. charge per acre	Air application: No. of jobs	Air application: Total acres	Air application: Ave. acres per job	Air application: Ave. appl. charge per acre
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
Gram 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

Table 11. (cont.)

Crop or land use	Ground application: No. of jobs	Ground application: Total acres	Ground application: Ave. acres per job	Ground application: Ave. appl. charge per acre	Air application: No. of jobs	Air application: Total acres	Air application: Ave. acres per job	Air application: Ave. appl. charge per acre
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

Table 11. (cont.)

Crop or land use	Ground application				Air application			
	No. of jobs	Total acres	Ave. acres per job	Ave. appl. charge per acre	No. of jobs	Total acres	Ave. acres per job	Ave. appl. charge per acre
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

Other

A limited amount of commercial work was done in combinations of jobs such as pesticides and fertilizers applied simitaneously. Seeding is also included under this classification. Very little is yet known as to the practicality of some of these operations. There has been a need however to reseed ranges and forest lands, and the airplane has proved useful in this type of work.

Seeding and the combination of seeding and fertilizing contributed most of the "other" type of operations. Seven hundred and fifty acres in this category were treated in 19 jobs. Most of the seeding was ryegrass, with clover, other grasses, and beans making up the remainder (Table 11).

CONSIDERATION OF SPECIFIC CROPS

Procedure

Ten representative crops were selected for more detailed analysis. Selection was based on the amount (total jobs and acres treated) of custom work done within the major groupings of cereals, grasses, legumes, tree fruits and nuts, small fruits, and vegetables. The crops finally selected were wheat, ryegrass, vetch, clover, cherries, filberts, strawberries, beans, canning peas, and potatoes.

The work done on each crop is summarized according to the purposes for which the applications were made. In each case the material is indicated. Within each pest group are shown the total acres and the number of jobs done with each chemical or fertilizer, and including the number of pounds applied per acre as well as the application charge.

No attempt will be made to compare the commercial work done on different crops. The representative crops include both intensive and extensive types of farming, and therefore measures such as total acres, number of jobs, and application charges have little comparative value.

Wheat

In this study, more commercial work was done on wheat than any other crop. Nearly 32 per cent or 34,728 acres received custom work, either in the use of herbicides, or fertilizers. Table 12 gives a summary of how these were applied.

Three types of fertilizers were applied to wheat, namely, ammonium nitrate, urea and anhydrous ammonia. Ammonium nitrate was used almost to the exclusion of the others. Because of this, its application charge of $0.95 an acre can be considered as the average for the entire fertilizer work done on wheat in this study.

As shown in Table 12, the herbicide, 2,4-D was used in nearly every application for weed control. The three

Table 12. Summary of all commercial work done on wheat: Pests, chemicals, number of acres, jobs, pounds of chemical applied per acre and average per acre charge for application.

Pest or operation	Chemical or fertilizer	Total acres	No. of jobs	Lbs. of chem. applied per acre	Average charge* for application per acre
Fertilizer	Ammonium Nitrate	7,564	31	69.0	$ .95
	Urea	36	3	87.0	1.25
	Anhydrous Ammonium	262	1	69.0	1.00
Tarweed	2,4-D	3,431	12	.8	1.06
Tarweed and Mustard		6,028	29	.9	1.14
Tarweed-Yardweed		3,889	10	.7	1.02
Mustard		1,713	12	1.0	1.16
Mustard Comb.	2,4-D	6,140	28	.8	1.08
Russian Thistle-Yardweed	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
	Dinitro Gen.	20	1	1.0	2.50
Pigweed-Fanweed	2,4-D	106	1	.8	1.09
"Weeds" Unknown	2,4-D	2,005	27	.8	1.21
	Dinitro Premerge	11	1	4.5	2.00

Table 12. (cont.)

Pest or operation	Chemical or fertilizer	Total acres	No. of jobs	Lbs. of chem. applied per acre	Average charge* for application per acre
"Weeds" Comb.	2,4-D	172	5	1.1	$ 1.43
"Weeds" Vetch	MCP	9	1	.2	2.04
Yardweed	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 chemical charge.

exceptions were, one job each using dinitro general, dinitro premerge, and MCP. Per acre charges were substantially higher when these three were used. The 2,4-D application charges averaged between $1.00 and $1.25 per acre in most instances with a range from $1.00 to $2.07. Its usual application rate per acre was from 0.8 to 0.9 pounds, with a range from 0.6 to 1.1 pounds.

Twenty-one weeds or weed combinations received chemical treatment. Single weeds are listed separately, but some of the combinations of two weeds were combined when the chemical and its application rate and charge per acre were similar. An example of this is "lambs quarter and combinations", which indicates that lambs quarter was listed in every case, but with different pests. The major pests, in point of acreage, were "mustard and combinations", "tarweed and mustard", and "tarweed and yardweed" (Table 12).

Ryegrass

Ryegrass was chosen to represent the commercial work done on grasses. All of the ryegrass work was done by aerial application. This was true of most grasses and so ryegrass, the one with the most acres treated, was selected. There were 14,278 acres of ryegrass treated in 185 jobs. The work included fertilizing, "other", and weed control. Table 13 lists the specific jobs.

Table 13. Summary of all commercial work done on ryegrass: Pests, chemicals, number of jobs, total acres, application charge per acre and pounds of chemical applied per acre.

Pest or operation	Chemical or fertilizer	Acres treated	No. of jobs	Lbs. of chemical applied per acre	Average charge* for application per acre
Fertilizer	Amm. Phos	745	4	195.0	$ 1.95
	Amm. Phos.-Amm. Nitrate	57	1	135.0	1.60
	Amm. Phos.-Urea	174	2	172.0	1.96
	Amm. Sulp.	5,290	76	186.0	2.07
	Amm. Sulp.-Nitrate	75	1	168.0	1.93
	Amm. Sulp.-Nitrate-Urea	143	1	100.0	1.25
	Amm. Sulp.-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, Unknown	2,4-D	407	7	1.2	1.36
	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 chemical charge.

Twelve fertilizers or fertilizer combinations were used on this crop with ammonium sulphate and ammonium nitrate being more commonly used. Ammonium sulphate consisting of 76 custom applications on 5,290 acres constituted nearly half of the fertilizer work. It was applied at a rate of 186 pounds and the average charge was $2.07 per acre. Each fertilizer was applied at a different rate and charges for application varied with the applicator and the pounds of material applied per acre. The application charge ranged from $1.25 to $2.43 per acre with $1.84 being the average for all such jobs.

It is of interest to not that ryegrass was seeded from the air in ten different jobs covering 383 acres. Twenty pounds per acre was the average seeding rate and the charge was $1.34 per acre for the application.

Two separate chemicals and one chemical combination were used in controlling four weed classifications, namely vetch, garlic and onion, grasses, and unknown weeds. The majority of all herbicide work done on ryegrass was to control annual grasses. Chloro IPC was used exclusively for this purpose. On the 2,374 acres thus treated, 2.0 pounds were applied per acre at an average charge of $1.02.

Table 14. Summary of all commercial work done on vetch: Pests, chemicals, total acres, number of jobs, average application charge per acre and number of pounds of chemical applied per acre.

Pest or operation	Chemical or fertilizer	Acres treated	No. of jobs	Lbs. of chemical applied per acre	Average Charge* for application per acre
Fertilizer	Gypsum	50	1	100.0	$ 1.24
Defoliation	Dinitro General	93	4	1.4	2.50
Leaf Tier	Malation	19	2	1.3	1.58
Weevil	DDT	8,540	219	.9	1.55
	DDT-Parathion	42	1	-----	1.76
Weevil-Aphid	DDT	45	1	1.0	1.40
	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 chemical charge.

Vetch

The total acreage of vetch treated in this study was 8,872, and the number of jobs, 231 (Table 14). Commercial chemical applications were in the three areas of fertilizer, defoliation and insect control.

Insect control was the only area of importance. Four insects or insect combinations were treated with three different chemicals--DDT being by far the most important. Over 96 per cent of the total vetch work was done to control a single pest--the weevil. For all intents and purposes, DDT was the only chemical used and it was applied at the average rate of 0.9 pounds to the acre for which an average application charge of $1.55 an acre was made.

Clover

Clover received a large variety of commercial work, including fertilizing, seeding, defoliation, weed, and insect control. In all a total of 2,864 acres of clover was treated in 130 jobs. The average charge for all of the work was $1.79 an acre. Table 15 summarizes the commercial work done.

Four different herbicides were used to control weeds, and one was used as a defoliant. The majority of the weed control work was to kill vetch in the clover through the

Table 15. Summary of all commercial work done on clover: Pests, chemicals, number of acres and jobs, application charge per acre and pounds of chemical applied per acre.

Pest or operation	Chemical or fertilizer	Total acres	No. of jobs	Lbs. of chemical applied per acre	Average Charge* for application per acre
Fertilizer	Ammonium Sulphate	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" unknown	MCP	4	1	.2	2.00
Grass	Chloro IPC	130	2	3.5	1.29
	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
	Toxaphene	160	6	3.0	1.76
	Aldrin	15	1	1.0	1.00

Table 15. (cont.)

Pest or operation	Chemical or fertilizer	Total acres	No. of jobs	Lbs. of chemical applied per acre	Average Charge for application per acre
Nitidulids	DDT	15	1	1.5	$ 1.87
	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 Ticks	DDT-Sulphur	12	1	----	1.50
Unknown insects	DDT	60	5	2.2	1.73
	DDT-Malathion	8	1	----	1.12
	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 chemical charge.

use of a selective herbicide, MCP. This treatment in which a chemical can be used to control one legume "weed" growing withing another legum crop is a good example of the progress being made in the current day development of selective weed killers. Nearly all of the MCP applications were at the rate of 0.4 pounds per acre of the active ingredient. The application charge was $2.04 per acre. Chloro IPC, IPC and 2,4-D were the other chemicals used.

Dinitro general was applied as a defoliant on 27 jobs entailing 522 acres. The chemical was put on at the rate of 1.4 pounds per acre and the average charge for this was $2.40.

Control of the lygus bug and its combination with the midge constituted most of the insecticide work. Weevils and Nitidulids were also important. Seven insecticides or combinations were used in controlling these pests with toxaphene being the most important. This chemical was usually applied at three pounds to the acre with the application charge between $1.60 and $1.80.

Cherries

Very little commercial chemical application work was done on cherries in comparison to most of the other nine crops; yet that which was done usually meant the difference between a saleable product and a complete loss. Chemical

Table 16. Summary of all commercial work done on cherries: Pests, chemicals, total acres, jobs, application charge per acre and pounds of chemical applied per acre.

Pest	Chemical	Acres treated	No. of jobs	Lbs. of chemical applied per acre	Average Charge* for application per acre
Brown Rot	Sulphur	11	2	45.4	$ 2.00
Weeds unknown	2,4-D	12	1	1.1	2.00
Caterpillar	Kolokill	23	1	50.0	3.26
	Rotenone	473	2	30.0	2.49
	DDT-Sulpheone	10	1	----	3.00
Cherry Fruit Fly	Kolokill	354	20	44.0	3.35
	Lead Arsenate	20	1	20.0	3.25
Synits Beetle	DDT	53	1	1.8	2.00
	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 chemical charge.

applications were made for the control of diseases, weeds and insects. A total of 1,047 acres was included in the sample and the average per acre charge of all types of custom work was $2.75. Table 16 summarizes all the custom work done on this crop.

The caterpillar and the cherry fruit fly were the two primary insect pests. Rotenone was used for caterpillar control, being applied at 30 pounds per acre with an application charge of $2.49. For the cherry fruit fly, 44 pounds of Kolokill was applied and $3.35 was charged for the application.

Filbert

Filberts had fewer acres commercially treated than any of the other nine crops. A total of 422 acres received custom work in 53 jobs. This work consisted of fertilizing, weed control, and insect control. The average per acre charge for all these was $1.95.

Table 17 shows that the only applications of consequence were for insect control. Five insects or insect pest combinations received custom treatment. They were the tent caterpillar, filbert moth, filbert leaf roller, leaf tier and a leaf roller-caterpillar combination. For their control, DDT and lead arsenate were the more commonly used chemicals. The filbert moth was the most prevalent pest having nearly half the total acreage that was treated.

Table 17. Summary of all commercial work done on filberts: Pests, chemicals, total acres, number of jobs, application charge per acre and pounds of chemicals applied per acre.

Pest or operation	Chemical or fertilizer	Acres treated	No. of jobs	Lbs. of chemical applied per acre	Average Charge* for application per acre
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
	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
	Lead Arsenate	5	2	1.6	2.20
Total		422	53	----	$ 1.95

* Application charges do not include chemical charge.

Lead arsenate was applied at 16.3 pounds per acre and at an application charge of $2.12.

Strawberries

The total custom applications to strawberries was 2,397 acres and the number of jobs, 112 (Table 18). The work consisted of fertilizing, weed control, defoliation, disease, and insect control. For all of the variety of application, $2.75 per acre was charged.

The four fertilizers applied to strawberries were ammonium phosphate, urea, uran, and IPC (an herbicide) and urea combination. Urea alone was of consequence and was applied at the rate of 48 pounds per acre to 656 acres in 23 jobs. The average charge was $2.41 per acre.

Strawberries were treated for three diseases, namely mold, fruit rot, and mildew. The chemical captan was used to control mold and mildew at an average rate of 2.0 and 2.7 pounds per acre respectively. The per acre application charge for mold treatments was $2.00 and for mildew, $5.00 per acre. The other disease, fruit rot, was treated with 3.8 pounds of ziram at an average application charge of $2.50 per acre.

One insect, the leaf tier, received more chemical applications than the other three insects combined. Nine different chemicals or chemical combinations were applied in varying amounts (Table 18) with the average per acre

Table 18. Summary of all commercial work done on strawberries: Pests, chemicals, number of jobs, acres, application charge per acre, and pound of chemical applied per acre.

Pest or operation	Chemical or fertilizer	Acres treated	No. of jobs	Lbs. of chemical applied per acre	Average charge* for application per acre
Fertilizer	Amm. 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	ATZ-Dalapon	2	1	-----	-----**
Pigweed	2,4-DS	25	4	2.4	2.20
Weeds unknown	Dinitro Premerge	32	4	3.0	4.23
	Dinitro General	13	2	1.4	5.69
	Dinitro General-IPC	4	2	-----	3.33
Defoliation	Dinitro Amne	60	8	2.6	4.50
	Dinitro General	283	19	1.4	4.84
Mold	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-Cop.-Sulph.	50	1	-----	2.00
	DDT-Mala.-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
	Sulphur	10	1	40.0	3.00

Table 18. (cont.)

Pest or operation	Chemical or fertilizer	Acres treated	No. of jobs	Lbs. of chemical applied per acre	Average charge* for application per acre
Strawberry Root Weevil	Aldrin	107	1	4.4	$ 2.38
	Chlorodane	95	3	3.0	2.50
	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 charge for chemicals.

** The ATZ-Dalapon job on annual bluegrass was done on an experimental basis and no charge made.

charges ranging from $2.00 to $3.75.

Beans

Custom work on beans consisted of fertilizing and chemical controls for disease, weeds and insects, with the latter of primary importance. The average charge for all of these applications regardless of type was $2.37 an acre. Table 19 is a complete summary of all custom work done on beans.

Weed control was a very important part of the custom bean work. The use of dinitro premerge on unknown weeds contributed nearly the entire sample. This chemical was applied at the rate of 1.3 pounds of the active ingredient per acre and at a charge of $2.25 for each of the 968 acres thus treated.

Eight insects were treated with eleven different chemicals or chemical combinations. Aphids and cucumber beetles were the more commonly treated insects, and malathion was primarily used for their control. For aphid control, the average application rate for malathion was 2.0 pounds per acre, and the charge, $2.22. For the cucumber beetle, 1.7 pounds of the actual chemical was applied at an average charge of $2.28 per acre.

Table 19. Summary of all commercial work done on beans: Pests, chemicals, total acres and jobs, application charge per acre and pounds of chemical applied per acre.

Pest or operation	Chemical or fertilizer	Acres treated	No. of jobs	Lbs. of chemical applied per acre	Average charge* for application per acre
Fertilizer	Nitrate	40	2	150.0	$ 2.08
	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
	Dinitro Prem.	19	2	3.9	2.47
Weeds unknown	2,4-D	38	1	1.0	2.43
	Dinitro Prem.	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
	Cop. Sulp. 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-Sulphur	8	1	-----	3.00
	Malathion	190	2	1.7	2.28
	Methoxychlor	10	2	2.0	3.60
	Sulphur	92	1	40.0	2.25
	TEPP	46	1	.4	3.73

Table 19. (cont.)

Pest or operation	Chemical or fertilizer	Acres treated	No. of jobs	Lbs. of chemical applied per acre	Average charge* for application per acre
Cucumber Beetle-Nitid.	DDT-Parathion	115	2	---	$ 2.41
Beetles unknown	Cop. Sulp. DDT	42	1	---	2.76
Nitidulids	DDT	14	2	1.8	3.14
	Malathion	5	1	2.0	3.00
	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 chemical charge.

Canning Peas

All of the commercial chemical applications on canning peas were either herbicides, or insecticides with most of the work done in the latter area. On 169 jobs a total of 6,163 acres were treated at an average charge of $2.24 per acre for the application (Table 20).

The pea weevil, aphids, and a combination of the two were the insects for which control was sought. The acreage treated for the pea weevil constituted over half of the total cannery pea acreage in the study. DDT and malathion were the main chemicals used for its control. DDT applied at 1.3 pounds per acre, had an application charge of $1.87. When malathion was used these averages were 2.0 pounds of chemical, and a $2.67 charge.

Potatoes

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

Blight was the serious disease pest in potatoes. For its control dithane, zineb and a copper-DDT combination were used. The per acre application rate varied with the

Table 20. Summary of all commercial work done on canning peas: Pests, chemicals, total acres and jobs, application charge per acre and pounds of chemical applied per acre.

Pest or operation	Chemical	Acres treated	No. of jobs	Lbs. of chemical applied per acre	Average charge* for application per acre
Pigweed	Dinitro General	50	2	1.1	$ 2.50
Weeds (unnamed)	2,4-D	430	2	1.0	1.00
	Dinitro General	44	2	1.1	2.50
	Dinitro Prem.	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-Sulphur	16	1	----	1.50
	Malathion	72	2	1.2	1.45
	Parathion	331	15	.5	2.50
Total		6,163	169	----	$ 2.24

* Application charge does not include chemical charge.

Table 21. Summary of all commercial work done on potatoes: Pests, chemicals, total acres and number of jobs, and application charge per acre, and number of pounds of chemical applied per acre.

Pest or operation	Chemical or fertilizer	Total acres	No. of jobs	Lbs. of chemical applied per acre	Average charge* for application per acre
Fertilizer	Urea	24	2	101.0	$ 0.34
	Nitrogen Solu.	8	1	11.0	2.93
Weeds unknown	MH-40	64	1	7.0	2.15
Defoliation	Dinitro General	4	1	.8	4.00
	Sod. Arsenate	139	15	4.0	2.50
Blight	Copper-DDT	146	4	---	2.51
	Dithane	308	4	1.0	2.11
	Zineb	430	3	2.4	2.25
Blight-Mosquitoes	Sul.-Cop.-DDT	100	1	---	2.25
Aphid-"Beetles" Flies 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-Sulphur	178	4	---	1.44
Tuber Flea Beetle	DDT	51	1	1.0	2.50
	DDT-Copper	36	1	---	2.50
	Aldrin	42	2	2.4	1.93
Roller	DDT	71	1	.8	1.74
	DDT-Malathion	352	3	---	1.75
Wireworm	Aldrin	322	4	1.8	2.39
Wireworm-Fleas	Dithane	165	1	1.0	2.00
Insects unknown	DDT	9	1	1.6	1.77

Table 21. (cont.)

Pest or operation	Chemical or fertilizer	Total acres	No. of jobs	Lbs. of chemical applied per acre	Average charge* for application per acre
Wireworm-Fleas		160	1	1.9	$ 2.37
Insects unknown	DDT-Sulphur	22	2	---	1.50
Total		7,498	194	---	$ 1.84

* Application charge does not include chemical charge.

chemical while the charges averaged about $2.25 per acre (Table 21).

There were nine insect pests treated in potatoes. Because of the similarity between aphids, beetles, flies and leaf hoppers as to application rates and charges and types of chemicals used, these pests were grouped together. This grouping of insects received the most work, using DDT and, DDT and malathion combinations primarily. The average per acre charges were $1.70 and $1.69 respectively while the rate of application for DDT was 1.5 pounds per acre.

ECONOMIC ASPECTS OF PESTICIDE APPLICATION

The preceding section of this chapter presented a summary of all the commercial work done on ten representative crops included in the study. Information about the specific pests treated, and the chemicals used for that purpose were presented. Also included were the pounds of active chemical applied per acre and the charges made for application. To complete the review of the chemical applications to these crops, it is desireable to know the total costs of control measures in relation to the amount of increased production needed to pay that cost. This is shown in Table 22.

For each of the ten crops just discussed, representative pests were chosen, and the price for the

Table 22. Economic aspects of pesticide application: Crop and pest, chemical used, total chemical and application charge per acre, average farm price received for crops, and estimated increase in yield necessary to pay for the chemical control.

Crop and Pest	Chemical used	Total chemical and application charge per acre (per application)			Average farm price for crop (5 yr. average)	Per acre yield increase needed to pay for control
		Application	Chemical	Total		
Wheat						
Tarweed-Mustard	2,4-D	1.14	.64	1.78	$0.035	50.80 pounds
Mustard-Comb.	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 unknown	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 Fruit Fly	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						
Aphid	Malathion	2.22	4.42	6.64	$0.064	103.70 pounds
Unknown Weeds	Dinitro Prem.	2.25	2.21	4.46	$128.32 per ton	69.60 pounds
Canning Peas						
Unknown Weeds	2,4-D	1.00	.71	1.71	$87.32 per ton	38.80 pounds
Weevil	DDT	1.87	.72	2.59	$0.044	58.80 pounds
	Malathion	2.67	4.42	7.09		161.00 pounds
Potatoes						
Aphids, Fleas, Leaf Hopper and Beetles	DDT	1.70	.82	2.52	$2.07 per cwt.	120.00 pounds
Wireworm	Aldrin	2.39	3.96	6.35	$0.021	302.30 pounds

important chemical used on each pest was determined from price lists of chemical companies. The chemical price and the charge for application were then added to obtain the total charge per acre figures presented here.

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

The total cost of the chemical application to the farmer varied markedly depending on the chemical used and its method of application. Some pests were easily controlled with light applications of inexpensive chemicals. DDT and 2,4-D are examples. Other pests required heavier applications of chemicals or very expensive ones to get the desired control. The range in the total costs, per acre, for the commercial work done on the selected crops was from $1.65 to $12.06 per application (Table 22).

The period of time for which the chemicals remained effective was quite different. Some pests required successive chemical applications within a single season. The cherry fruit fly was one such pest. Others could be controlled by one application during the life of the crop. Aldrin applications on the strawberry root weevil controls in this residual fashion. In order to get an accurate estimate on the total cost of controlling the various pests it follows that the number of applications per year must be added when there is more than one, and when a residual chemical control is used, the cost must be prorated for the years of its effective life.

The effectiveness of chemical control measures applied to such pests as insects is difficult to estimate. Environmental conditions such as the moisture available or the temperature during the growing season of the host may exert a great influence on how the pests react to treatments. In Chapter 4, a discussion of the factors that influence the effectiveness of pesticide treatments will be presented. Many of the crops in the study were grown in widely different areas of Oregon and the results achieved may be indicative of local conditions but could vary with the locality. This is especially true of herbicide work.

Insects and diseases cause losses primarily in two ways, through damage to some part of the structure of the plant or to the product for which the crop is grown. The latter is the more readily evident and usually will be the reason why insecticides are applied, for it may mean the difference between a saleable product and a partial or complete loss. Cherries, vetch and peas are examples of crops whose product can be damaged to the extent that it is not acceptable. The strawberry root weevil is an example of a pest which attacks the plant structure and reduces yields.

For the crops that are only partially damaged by insects or diseases, and the product can be sold if sorted, the loss comes in two forms; first, in a direct loss of income for all the product that must be sorted out as unacceptable, and secondly, the additional operational expense of the sorting process.

Net Economic Advantage of Pest Control

Based upon the results of the study, the data in Table 22 presents an estimate of how much product is needed to pay for control of selected pests on each of ten crops. The significant thing to note is how small those regional fields (column 7, Table 22) were in every case. An example is as follows: when the vetch weevil was controlled with DDT, the total cost of the chemical and its application was $2.05 per acre. If vetch were selling for 5.8¢ a pound, it is estimated that only 35.3 pounds would be necessary to pay for the control measures taken. To control the "midge-lygus" combination in clover using toxaphene the cost was $3.46 per acre for the chemical and its application. When clover sells for 25.5¢ a pound, 13.6 pounds of seed would pay for each acre of insect control. In cherries, the control of the fruit fly is necessary if the crop is to be sold. Usually three applications of chemicals are necessary to effect satisfactory control. Assuming three applications of Kolokill were made at $7.75 (Table 22) an application, the total cost of the control measures would be $23.25 per acre. It would take 175 pound of cherries to pay for the controls if cherries sold for 13.3¢ per pound. Assuming fifty cherry trees per acre, only 3.5 pounds of cherries from each tree would pay for all the chemical control measures for the cherry fruit fly. Without this control the crop cannot be sold.

Chemical weed control results are easily seen. It is self evident that "weeds" growing in a crop compete directly and very effectively for plant nutrients and soil moisture. If the weeds were controlled these nutrients would be available for the growing crop. Not only would this increase production but it would decrease product contamination with foreign materials, thus improving the quality and value of the product. Control of annual grasses in ryegrass has this dual purpose because as a seed crop, it must be uncontaminated. Using chlora IPC for this purpose, the chemical and its application cost $4.42 an acre. If ryegrass sold for 10.4¢ (Table 22) an estimated 42.5 pounds of the crop would pay for the control. Even with ryegrass selling for 4.5¢ a pound, one hundred pounds would more than pay for the chemical treatments. Not only is the yield per acre increased when annual grasses are controlled but the quality of the seed is also improved.

One of the best examples of the actual results that can be expected from chemical weed controls is from the experimental data on wheat. A three year average of yield increases 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 can be expected from weed control. Table 22 indicated that the cost of both the chemical and its application were more than paid for by a single bushel of wheat increase. Therefore in every case the weed control experiments on wheat more than paid for themselves.

CHAPTER IV

PESTS AND INFLUENCES AFFECTING THEIR CONTROL

The preceding chapter was concerned with all the crops and land uses on which commercial applications were made. Part of that section presented data on specific pests and specific chemicals in relation to individual crops, representative of the entire study from the standpoint of pests involved and chemical treatments applied.

For each of the ten, information was given as to the pests, and the chemicals used for control. Also included were the total acres and jobs treated with each chemical and its average per acre rate of application and money charge. These pests, however, represented only a partial list of all the pests included in the entire study. Some pests, especially the weeds, were found in many crops and land uses, while others were confined primarily to one or two crops.

In this chapter principal attention is directed to the pests, and to some of the factors that are important influences in determining the effectiveness of chemical applications. All of the insects, diseases and weeds that were chemically treated by custom operators are listed; the time range of the actual treatment is indicated; the acres and jobs for both ground and air applications are shown; and finally, the names of the chemicals used on each specific pest are included.

FACTORS INFLUENCING THE SUCCESS OF PESTICIDE APPLICATIONS

It is not enough to procure effective pesticides and apply them. The best material may fail if it is used at the wrong time or in the wrong way. The chemical applicator quickly finds that there are a number of conditions that have a direct bearing on the effectiveness of the work being done. When these conditions are favorable, pest control is good; when some are unfavorable, then results may not pay for the job done. Many of the modifying factors can be controlled by the applicator, while others, by proper adjustment in methods and procedures, can be influenced greatly. Some unfavorable conditions cannot be foreseen or controlled. Unexpected adverse weather is a good example. The important thing is for the applicator to have as complete a background and knowledge of the controlling factors as he can, and adjust his operation accordingly, thus insuring himself of a consistently high level of performance.

To obtain a better understanding of the complexity of pesticide work, a brief discussion of some of the major influences on the success of chemical applications will follow. Pests will be considered in two general classes, insects which will include diseases, and weeds.

THE APPLICATION OF INSECTICIDES

Few if any of Oregons' many agricultural crops are immune to insect attack. Insect control has proved profitable in the production of many crops. Most of our fruit crops could not be commercially marketed if insect infestations were not controlled. Rather closely allied in many respects to insects, is the control of plant diseases. The factors influencing successful applications will be nearly the same in both cases.

Insecticides Applied to the Crop

Correct identification of the species of insect is of the utmost importance in determining whether a given chemical will meet the problem of protecting the crop. There are some chemicals which can control quite a variety of insects, yet some species of insects are most economically controlled by only one chemical. By wrongly identifying an insect, the subsequent use of an inappropriate chemical may cause the farmer to lose the cost of the application, the cost of the chemical and to suffer a partial or complete loss of crop due to the insect damage.

Once the pest is properly identified, it is necessary to know when, or at what stages in its life cycle, the insect attacks the crop. By knowing when the attack begins and its duration, the applicator can find the best time to control it. If applied too early, insecticides may be dissipated before the pest is present or in a susceptible condition. If applied too late, the damage is already done.

The properties of the chemical itself may have a direct bearing on the success with which it is applied. Vapor pressure, water solubility, sunlight, and moisture affect life of the spray. These physical differences can be quite advantagous in many respects. Some chemicals have a prolonged residual life, while others are short lived and deactivate in a few hours. If continuous protection from insects is needed then a residual chemical will be best. If an immediate insect kill is desired, with no toxic residue after a short time, then a chemical is needed that will quickly dissipate.

Nature plays an important role in the effectiveness of the application of insecticides to plants and other surfaces. Wind and air currents limit the times when applications can be made. A current of air over ten miles per hour will make it nearly impossible to effectively control dusts and sprays. That is, with its accompanying possible damage to other crops, drift is always a constant danger with any wind.

Temperature becomes important in the application of insecticides only when it is extreme. Most materials are safe and effective at ordinary temperatures. There is danger of injury to fruit and foliage if some materials are used in hot weather, although their effectiveness is not lessened.

Moisture presents different problems. Rain may wash off insecticides, especially those soluble in water and their effectiveness is lost. Where oil emulsions are used, moisture in the form of dew on leaves or other surfaces may result in poor deposits of the chemical. If a chemical is readily broken down by moisture, a period of high humidity following application may cause excessive loss of the insecticide.

Soil Application of Insecticides

In using insecticides for the control of insects in the soil, many of the same general considerations that applied to crop applications would hold true, as well as some others. Some of the various features that determine chemical effectiveness in a particular soil are as follows: the rapidity with which the chemical is tied up or absorbed by the soil, the type and texture of the soil, and the acidity or alkalinity of the soil. In general, organic matter and clay particles absorb the chemical more rapidly than sandy or coarser soil particles. The rapidity of breakdown and leaching of soil insecticides are influenced by climate, soil type, bacterial action and the make up of the chemical itself.

Under high temperature conditions, vaporization of insecticides applied to the surface of the soil may reduce substantially the amount of chemical left in the soil. Where the chemical is to be incorporated into the soil, tillage should follow as soon as possible, particularly in period of high temperature.

THE APPLICATION OF HERBICIDES TO KILL WEEDS

The advent of selective herbicides and their rapidly increased use, has increased the need for information pertaining to their most effective and safest use. Various factors such as the chemical properties and the physiology of the plant, as well as the chemical-plant relationship are important factors to know. If the chemical applicator is well informed on these things, he can take advantage of them.

Foliage Application

The species of plant must be known to determine the response of that plant to a given chemical. If the species is known then such information as the location of growing points, waxy covering on leaves, and the actual biochemical sensitivity to the herbicide is usually available. Morphology or structure of the plant is important when determining the most effective means of application. As an example, if the growing point is buried deep in tissue or protected by leaves, the applicator must choose a chemical that can reach this growing tip. The chemical could be applied in large quantities in order to completely cover the plant and thus reach the growing points or a chemical could be applied that could be absorbed and translocated to the growing points. As a reaction to adverse growing conditions some plants develop waxy coverings which the chemicals must penetrate. In general, oil like materials will penetrate more readily than others.

The growth habits of a plant are important. In dormant seasons spraying will be of little value. Also a plant at different ages will have different responses to a given chemical. They may be quite resistant to the herbicide at some stages, while at others, extremely sensitive. As a general rule as plants advance in maturity they become more resistant. It is well to mention that this principle applied equally well to the commercial crop to be saved and to the weeds to be controlled. Therefore caution must be used not to apply chemicals too early when the crop could easily be damaged as well as the weeds. A good example is the too early application of 2,4-D to young wheat plants in an effort to kill tarweed. The tarweed will be controlled but the wheat crop will be damaged also.

Absorption and translocation are still another relationship between the plant and the chemical. As a generalization, it can be said that the water soluble compounds are most readily absorbed by the plant roots and the oil-like materials are most readily absorbed by the leaves. One can increase the absorbtion by using various spray additions or different chemical formulations. The amount of translocation has a direct bearing on the best possible kill. If the chemical is absorbed too rapidly in the leaves, the top of the plant will die before the herbicide can be translocated to the roots. If this happens the roots remain alive and can send up a new plant. A moderate rate of absorbtion and reaction combined with translocation would give the best over-all kill.

Environmental influences upon the effectiveness of the herbicide treatments are nearly the same as they are for insecticides. There is however one important difference to be remembered. The environment effects not only the chemical, and the weed pest, but also the crop that is being treated. By considering the combination of all these, it is possible to obtain satisfactory results.

Soil Application of Herbicides to Kill Weeds

Herbicides when applied to the soil have two major uses; that of pre-emergent weed control, and soil sterilization. In using pre-emergent weed control, the chemicals used are selected on the basis that they are relatively non-injurious to the crop. The chemicals are used then in two ways; either the chemical has a bio-chemical selectivity, or the crop seed is planted so deeply that it does not come into contact with the chemical until the sprout is sufficiently well developed to withstand such exposure.

The rate of breakdown and loss of the chemical may be quite a problem. If it washes readily or volatilizes easily, it may be lost so rapidly from the soil that it is ineffective. Soils possess the ability to tie up or absorb chemicals. The degree to which this is done depends on the nature of the soil and the herbicide. For residual protection it would be vital to choose a chemical best suited for that purpose and soil.

In the actual application of the pre-emergent chemicals, moisture is very important. Optimum soil moisture is needed to get the correct distribution of the chemical in the soil horizon so as to bring it into intimate contact with the germinating weed seed. Fortunately it is probable that when the soil moisture is such as to give best crop growth, it is also best for pre-emergent treatment.

Soil sterilization work is influenced mainly by the soil and the climate and in the same general ways as the other herbicides and insecticides. In this type of pesticide control, a non-selective chemical is used to kill all vegetation present and have a residual or lasting effect so that new growth does not occur.

The agricultural use and application of chemicals has become a very exacting science. It is hard for each farmer to keep up with the latest information and often times the amount of chemical application work needing to be done on his own place will not justify the ownership of his own equipment. This situation has given rise to the development of custom chemical applicators and the sharply growing acreages being treated by them.

PESTS INCLUDED IN THE STUDY

Pesticide application in this study had one purpose--that of controlling pests on agricultural crops and land uses. The pests treated were of three main types, namely, insects, weeds and plant diseases. The chemical treatment of each of these pest groups will be discussed separately.

In Chapter III, "Crops Included in This Study", it became evident that nearly every major crop grown in Oregon has a pest problem. Some crops have several varieties of each of the above types of pests, while others were bothered by only one. Also, it is true that some pests only attack a single crop, while others can be found in a variety of crops. The latter is particularly true of weeds.

As a method of showing the extent and variety of pests included in the study, a complete list of single pests and pest combinations receiving chemical treatments is presented in Table 23. The table shows for every pest, the acres and number of jobs done by both ground and air equipment, and lists all the chemicals used in an effort to control each pest. Also a column has been included which will show the ranges of dates between which control applications were made.[2] As was evident in the preceding section of this chapter, the timing of the chemical applications for pest control is of vital importance in obtaining maximum protection to agricultural crops. Usually for insects and diseases, controls should be applied when the pest first attacks the crop. However, in some instances, best control results from an application just prior to such attack. For some pests, one application is sufficient to effect control while others require repeated treatments. In the application of herbicides, the physiology of both the weed plant and the crop must be considered. The proper time may vary with the weeds to be treated, the crops they are growing in, and the specific chemicals used for their control. If the

---

2 Each month was divided into two parts. If work done was on June 15, then it is shown as June 1-15. If the work was done June 16, then it is shown as June 16-30. If two similar jobs were done, one on June 15, and one on June 16, the range will appear as from June 1-30.

Table 23. Summary of all pests treated: Number of jobs, total acres, time range for treatments and chemicals used.

Pest	Time range	Number of jobs		Acres treated		Chemical used
		Air	Ground	Air	Ground	
Insects						
Aphid	Jun 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	Jul 1-Jul 15	4	---	266	---	DDT, Malathion
Suneta 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)	Jun 16-Jul 31	26	---	837	---	Sulfur, Copper, DDT
Clover Root Borer	Apr 16-Apr 31	---	2	---	18	Aldrin
Peach and Prune Root Borer	Jul 16-Jul 31	---	1	---	22	DDT
Borers (unidentified	May 1-May 15	2	---	27	---	Malathion
Lygus Bugs	May 16-Jul 31	19	---	506	---	Aldrin, DDT, Sulfur, Toxaphene
Tent Caterpillar	May 1-May 31	5	---	520	---	DDT, Kolokill, Lead Arsenate
Cherry Fruit Flies	May 16-Jun 31	20	2	393	5	Kolokill, Lead Arsenate
Grasshoppers	Jul 16-Aug 15	10	---	481	---	Aldrin
Leaf Hoppers	Jun 1-Jun 15	---	1	---	8	Malathion
Onion Maggot	Apr 16-Apr 30	1	---	19	---	DDT
Spider Mites	Jul 16-Jul 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-Jul 31	6	20	112	140	DDD, DDT, Copper, Malathion, Lead, Arsenate
Nitidulids	May 1-Jul 31	10	---	133	---	DDT, Malathion, Tepp, Toxaphene
Slugs	May 1-Jun 15	2	---	50	---	Bait
Symphyllids	Apr 16-Jun 15	---	2	---	13	Parathion
Filbert Leaf Roller	Apr 16-May 15	---	20	---	131	DDD, DDT
Roller (unidentified)	May 16-Jul 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-Jun 31	2	---	26	---	DDT, Kolokill
Clover Leaf Weevil	Apr 16-Apr 30	---	1	---	15	Aldrin
Pea Weevil	May -Jul 31	243	---	7,019	---	DDT, Malathion, Parathion, Rotenone

Table 23. (cont.)

Pest	Time range	Number of jobs Air	Number of jobs Ground	Acres treated Air	Acres treated Ground	Chemical used
Strawberry Root Weevil	Apr 1-Sep 15	1	21	40	201	Alsrin, DDT, Chlordane, Heptachlor
Vetch Weevil	May 16-Jun 31	220	----	8,583	---	DDT, Parathion
Weevils (unidentified)	Jun 16-Jun 31	1	----	35	---	Toxaphene
Cutworms	Apr 16-Jul 31	6	1	202	3	Aldrin, DDT
Wireworms	Apr 16-May 31	5	----	487	---	Aldrin, Dithane
Worms (unidentified)	May 1-Jul 31	4	2	148	2	DDD, DDT, Kolokill, Parathion, Tepp
Insects (unnamed)	Jun 1-Sep 30	12	1	144	13	Aldrin, DDT, Malathion, Sulfur, Toxaphene
		Two Insects				
Aphids-Flea Beetles	Jul 1-Jul 31	3	---	70	---	DDT, Malathion, Parathion
Aphids-Diabratica	Jul 16-Aug 15	9	---	493	---	DDT, Malathion
Aphids-Beetles (unidentified)	Jul 16-Jul 31	33	---	965	---	DDT, Malathion, Parathion, Sulfur
Aphids-Lygus Bugs	Jul 16-Jul 31	4	---	224	---	DDT, Malathion, Toxaphene
Aphids-Horn Flies	Jun 16-Jun 30	1	---	42	---	DDT, Malathion
Aphids-"Flies"	Jul 1-Jul 15	1	---	10	---	DDT, Malathion
Aphids-Leaf Hoppers	Jul 16-Jul 31	3	---	178	---	DDT, Malathion
Aphids-Midge	Jun 16-Jul 15	3	---	269	---	DDT, Malathion, Toxaphene
Aphids-Alfalfa Weevil	Jun 16-Jun 31	---	1	---	17	Aldrin, Malathion
Aphids-Wireworms	Jun 1-Jun 15	1	---	202	---	DDT, Captan, Diathone, Sulfur
Diabratica-Mosquitoes	Jul 1-Jul 15	1	---	98	---	DDT, Copper, Sulfur
Diabratica-Nitidulids	Jul 1-Jul 15	1	---	17	---	DDT, Parathion
Lygus Bugs-"Beetles"	Jul 16-Jul 31	1	---	20	---	DDT
Lygus Bugs-Clover Flower Midge	Jul 1-Jul 31	4	---	69	---	DDT
Lygus Bugs-"Midge"	Jun 16-Jul 31	37	---	879	---	Aldrin, DDT, Sulfur, Toxaphene
Lygus Bugs-Thrip	Jun 16-Jul 15	2	---	11	---	DDT, Toxaphene
Lygus Bugs-Alfalfa Weevil	Jul 1-Jul 15	1	---	5	---	DDT
Lygus Bugs-Clover Leaf Weevil	Jun 1-Jul 31	3	---	91	---	DDT, Toxaphene
Lygus Bugs-Clover Seed Weevil	Jul 16-Jul 31	1	---	10	---	Toxaphene
Lygus Bugs-"Weevils"	Jun 1-Jun 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-Jul 15	23	---	586	---	DDT, Malathion, Parathion, Sulfur
Pea Weevil-Vetch Weevil	May 16-Jun 15	8	---	343	---	DDT
Vetch Weevil-Aphids	May 16-Jun 31	2	---	53	---	DDT, Parathion
Weevils-Aphids	Jul 1-Jul 15	1	---	78	---	DDT
Weevils-Ticks	Jun 1-Jun 15	1	---	12	---	DDT, Sulfur
Wireworms-Fleas	May 16-May 31	1	---	160	---	Aldrin
Insects Sub-Total		947	86	32,379	668	

Table 23. (cont.)

Pest	Time range	Number of jobs		Acres treated		Chemical used
		Air	Ground	Air	Ground	
			Weeds			
Tarweed	Mar 16-May 30	12	---	3,431	---	2-4-D
Mustard	Mar 16-Jul 15	14	8	2,359	73	2-4-D
Russian Thistle	May 16-May 30	1	---	178	---	2-4-D
Vetch	Jan 1-Jun 15	6	20	1,850	380	2-4-D, DDT, MCP
Morning Glory	Mar 16-Sep 30	12	6	1,948	26	2-4-D
Canadian Thistle	May 1-Sep 15	23	57	1,263	542	2-4-D, ATZ, 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-Jul 1	19	10	542	139	2-4-D
Annual Bluegrass	Apr 1-Apr 15	---	1	---	2	ATZ, Dalapon
Cheatgrass	Apr 1-Apr 15	1	---	45	---	Dalapon
Tussock	Apr 16-Jun 1	---	2	---	16	2-4-D
Poison Oak	Feb 1-Jun 1	---	2	---	4	2-4-D, 2-4-5T
Wild Blackberry	Jun 1-Sep 1	---	3	---	17	2-4-5T Brush Killer 2-4-D/2-4-5T
Sagebrush	May 1-Jun 1	10	---	725	---	2-4-D
Tansy Ragwort	Jun 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, ATZ, 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
Yellow Star Thistle	Apr 16-Apr 31	---	3	---	20	2-4-D
Willow	Jun 16-Jun 30	1	---	36	---	2-4-D
Yardweed	Apr 16-May 15	3	---	433	---	2-4-D
Weeds (unnamed)	Apr 1-Nov 30	49	228	3,930	5,210	MH-40 (Parathion) Killer, 2-4-D, ATZ, 2-4-DS, Dinitro General, IPC, CMU, Hormotox, NACl, DCMU, Dinitro Amine
Grass	Mar 1-Nov 30	43	17	4,217	535	Chloro IPC, IPC, DCMU, 2-4-D, ATZ, Dalapon, Karmex DW
Brush	May 16-Aug 31	1	1	15	10	2-4-D, Brush Killer
Radish	May 1-Jul 1	---	23	7	337	2-4-D
Nettles	May 1-May 15	1	---	---	---	2-4-D
Sunflower	Jul 16-Jul 31		---	61	---	2-4-D
Defoliation	Jun 16-Nov 15	22	53	525	588	Dinitro Amine, Dinitro General, Sodium Arsenate
			Two Pests			
Canada Thistle-Filaree	Jun 16-Jun 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

Table 23. (cont.)

Pest	Time range	Number of jobs		Acres treated		Chemical used
		Air	Ground	Air	Ground	
Canada Thistle-Morning Glory	Jun 1-Sep 15	1	5	27	58	2-4-D
Canada Thistle-Lambs Quarter	May 16-Jun 15	---	2	---	40	2-4-D
Canada Thistle-Poison Oak	Jun 16-Jun 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	Jun 16-Jun 30	---	1	---	8	2-4-D
Canada Thistle-Tansy Ragwort	Jun 16-Jun 30	---	1	---	3	2-4-D
Canada Thistle-Pigweed	May 1-Jun 1	---	5	---	102	2-4-D
Canada Thistle-Weeds	May 1-Jun 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-Jun 30	---	12	---	243	2-4-D, ATZ
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-Jun 31	1	1	32	15	2-4-D
Lambs Quarter-Russian Thistle	Jun 1-Jun 15	1	---	15	---	2-4-D
Lambs Quarter-Pigweed	May 16-Jun 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	Jun 16-Jun 30	---	1	---	10	2-4-D
Cattails-Weeds	May 1-May 15	---	1	---	2	Ammate, Dalapon
Dandelion-Plantain	Jun 16-Jun 30	---	1	---	33	2-4-D
Hemlock-Dandelion	Apr 16-Apr 30	---	1	---	4	2-4-D
Pigweed-Sunflower	Jul 1-Jul 31	1	---	10	---	2-4-D
Yellow Star Thistle-Mustard	Apr 16-May 31	---	2	---	29	2-4-D
Yellow Star Thistle-Brush	Jul 16-Jul 31	---	1	---	3	Brush Killer
Weeds (unnamed)-Mustard	Apr 16-Jun 31	1	2	90	22	2-4-D
Grass-Wild Blackberry	Jun 1-Jun 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
Tarweed-Yardweed	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-Jun 30	---	7	---	67	2-4-D
Mustard-Canada Thistle	May 16-Jul 15	26	2	1,850	61	2-4-D
Mustard-Pigweed	May 1-May 15	1	---	551	---	2-4-D
Mustard-Radish	Jun 1-Jun 15	---	1	---	60	2-4-D

Table 23. (cont.)

Pest	Time range	Number of jobs Air	Number of jobs Ground	Acres treated Air	Acres treated Ground	Chemical used
Filaree-Russian Thistle	May 1-May 15	1	---	210	---	2-4-D
Russian Thistle-Yardweed	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	Jun 1-Jun 15	---	1	---	76	2-4-D
Grass-Weeds	Feb 1-Sep 15	---	21	---	128	Dinitro General, CMU, DCMU, Polybar, 2-4-D, 2-4-5T, ATZ, Borate, Borasau, chlorate, Dalapon
Brush-Weeds	May 1-Aug 31	---	2	---	5	Brush Killer
Sunflower-Mustard	Jun 16-Jun 30	1	---	248	---	2-4-D
Sunflower-Weeds	Jul 1-Jul 15	1	---	95	---	2-4-D
Fanweed-Pigweed	Jun 16-30	1	---	106	---	2-4-D
Defoliation-Weeds	Jul 1-Jul 15	---	2	23	27	Dinitro General
Fanweed-Weeds		1	---	23	---	2-4-D
		Diseases				
Mold	Jun 1-Sep 15	8	---	153	---	Captan, Malathion, Sulfur, Tepp, Ziram
Fruit Rot (Strawberry)	Jun 1-Jun 15	2	---	36	---	Ziram
Brown Rot (Cherry)	Apr 16-Jun 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	Jul 16-Aug 31	11	---	884	---	Copper, DDT, Dithane, Zineb
Rust-Weeds	May 1-May 15	---	1	---	277	Dinitro Amine
Lygus Bugs-Lambs Quarter	Jun 1-Jun 15	2	---	39	---	DDT, Toxaphene, 2-4-D
Walnut Blight-Mosquitoes	Jul 1-Jul 15	1	---	100	---	Copper, DDT, Sulfur
Leaf Spot-Aphids	Jul 16-Jul 31	6	---	182	---	DDT, Malathion, Parathion
Rust-Mint Leaf Beetle	Jul 16-Jul 31	1	---	240	---	DDT, Dichlone
Leaf Spot-Lygus Bugs	Jul 1-Jul 31	14	---	323	---	Copper,Sulphate, DDT, Parathion, Copper
Weeds Sub-Total		330	555	40,339	9,649	
Diseases Sub-Total		58	9	2,310	313	
Grand Total		1,335	650	75,028	10,630	
		1,985		85,658		

pest listed (Table 23) effects only one crop then the application time range is quite meaningful. If, however, it is a pest to several crops, as many weeds are, then the application time may vary directly with the crops involved and they must be known to correctly interpret the data.

In this study a total of 85,658 acres were chemically treated, in connection with 1,985 jobs, to control 65 individual pests and 84 combinations of pests. A total of 42 single chemicals or 38 combinations of chemicals were used for this purpose. The main type of insects, weeds, and diseases, as listed in Table 23, will be considered in that order. The leading species for each type of pest will be briefly discussed and presented in three separate tables, each extracted from Table 23.

Chemical Treatments on Insect Pests

In this study over 33,000 acres received insecticide applications to control 36 varieties of insect pests and 28 combinations of various varieties. These applications were accomplished in 1,033 jobs and represented 38.5 per cent of the complete pesticide sample in terms of acres. Twenty-two different chemicals were used either separately or in combination. DDT and malathion were the chemicals most commonly used. Nearly all the treatments were made from the air. A short list of the main insects treated is presented in Table 24.

Table 24. Summary of leading insects receiving chemical treatments: Total acres, time range for treatments and chemicals used.*

Leading insects	No. of jobs	Total acres treated	Time range for treatments	Chemicals used
Weevil (Vetch)	220	8,582	May 16-Jun 30	DDT, parathion
Weevil (Pea)	243	7,019	May 16-Jul 31	DDT, mala., para., rot.
Aphids	123	4,314	Jun 1-Oct 15	Cop., DDT, sul., mala. para., TEPP, sys., meth.
Aphids-Beetles	33	964	Jul 16-Jul 30	DDT, mala., para., sulf.
Lygus-Midge	37	879	Jun 16-Jul 31	Adlr., DDT, sulf., toxa.

* This data was extracted from Table 23.

The vetch and the pea weevil treatments combined constitued nearly half of the total insect work done. For the two, a total of 15,601 acres were treated in 463 jobs. The vetch weevil had DDT and parathion applied and the pea weevil had applications of these and also parathion and rotenone.

Other leading insects of the study were aphids and the aphids-beetles combination. Nine different chemicals were used for treating over 5,000 acres infested with these insects.

It is difficult to determine how closely the timing of the pesticide applications conformed to those recommended by the college. This is partly due to the fact that the actual date of treatment was not summarized any closer than the "first half" or the "last half" of the month. For the vetch weevil the college recommends application of controls on June eighth plus or minus a week depending on the season and elevation of the vetch crop. As Table 24 shows, the range of dates of the study applications for this pest was from May 16 to June 30. As suggested previously, May 16 and June 30 could be considered as "outside" dates because of the manner in which the application dates were summarized. The "inside" dates for the treatment of the vetch weevil in this study could very well have been May 31 and June 16. In order to be effective, according to the College recommendations, these applications would have had to be made on the last day or two of May or the first few days following June 16. Therefore, it would appear that the custom operator treatment dates may have conformed quite closely to those recommended by the College.

The application dates of pesticides for control of the pea weevil were influenced by several things. Much of the weevil control work was done on canning peas which usually are grown to mature at different times in order to facilitate handling and processing at the cannery. To accomplish this, planting dates are staggered and different varieties grown. With different maturing dates, the weevil attacks the peas at different times and must be controlled when it appears. In addition repeated pesticides applications may be necessary for weevil control on the canning pea although usually one treatment is enough for field peas. The combination of several of these factors are the reasons for the range in application dates (Table 24).

The aphid, the other major insect pest, is an insect which attacks a variety of different crops and for which repeated applications of chemicals are usually necessary. The proper time for application will vary with the crop being protected and the aphid infestation.

<u>Chemical Treatment on Weed Pests</u>

More weeds were treated for chemical control than any other pest in the study. Over 58 per cent (50,088 acres) of the chemical treatments made were on 29 varieties of weeds and 50 combinations of weeds. This work was done in 885 jobs--555 by "ground" and 330 by "air". Over 90 per cent 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.

Twenty-five chemicals were used separately or in combinations of two, three or four chemicals for herbicide purposes (Table 23). The only chemical of real importance as far as acreages treated is concerned, was 2,4-D, either by itself or in combinations. Table 25 is a summary of the leading weeds treated in the study.

"Weeds" (unnamed) was the category with the largest acreage receiving chemical treatments. This "catchall" designation was used by the applicators when they did not know the specific variety of weed or weeds they were treating or when they were treating several kinds and just "lumped" them into one category. Undoubtedly both annual and perennial weeds of many different types are included. The majority of the "weed" treatments were done by ground equipment in the Willamette Valley, where smaller jobs

Table 25. Summary of leading weeds receiving chemical treatments: Number of jobs, total acres, time range for treatments and chemicals used.*

Leading weeds	No. of jobs	Total acres treated	Time range for treatments	Chemicals used
"Weeds" (Unknown)	277	9,140	Apr 1-Nov 30	IPC, horm., Brushklr., 2,4-D, CMU, ATZ, DCMU, 2,4D-S, MH-40, Dinit.-Ammine, dinit. gen.
Grass	60	4,752	Mar 1-Nov 30	Chloro IPC, IPC, DCMU, 2,4-D, karm., dalapon
Tarweed-Mustard	35	7,471	Apr 1-May 30	2,4-D
Tarweed-Yardweed	9	3,810	Apr 1-May 30	2,4-D

* Extracted from Table 23.

predominated and a diversity of weeds was found. Emphasizing the importance and the diversity of weed control problems in Oregon it is significant to note that eleven chemicals were used for control purposes, extending over a period of eight months (Table 25).

Grass, a similar "catchall" grouping, included treatments ranging from annual grass in perennial grass seed crops to jobs such as grass growing around buildings and along roadways. Seven different chemicals were applied in a nine month period.

Tarweed in combination with mustard, and with yardweed formed the other leading weed pest groups. These weeds, growing in cereal crops (primarily wheat) in Eastern Oregon, constituted eleven thousand acres in 44 jobs. The herbicide 2,4-D was used exclusively and applied on dates ranging from April 1, to May 30. The application dates recommended by Oregon State College for these conditions are from March 15 to April 15. Treatments applied after the latter date usually do not give a satisfactory control.

Chemical Treatments of Plant Diseases

Very few commercial pesticide treatments were made to control plant diseases. Some applications were made to control a single disease, and other were made in an attempt to control another type of pest as well. Six

Table 26. Summary of leading disease pests receiving chemical treatment: Number of jobs, total acres, time range for treatments and chemicals used.*

Leading diseases	No. of jobs	Total acres treated	Time range for treatments	Chemicals used
Mildew	13	354	May 1-Aug 15	Capt., cop. sulphate, diathone, sulfur
Mold	8	153	Jun 1-Sept 15	Capt., malathion, sulphur, TEPP, ziram
Leaf Spot and Lygus Bug	14	323	Jul 1-Jul 31	Copper, sulphate, DDT, parathion, copper

* Extracted from Table 23.

single diseases, four combinations diseases and insects, one disease and weed combination, and a weed-insect job comprised the 2,623 acres that were treated in 67 jobs (Table 23). Fifteen chemicals were used either separately or in combinations for control purposes. Table 26 is a summary of the major pests of this type.

Mildew was the important plant disease pest. Between May 1 and August 15, 354 acres were treated in 13 jobs. The chemicals used for its control were captan, copper sulfate, diothone and sulphur. The second important disease, mold, had a total of 153 acres treated.

Five different chemical or their combinations were applied as pesticides. Because different crops were affected by the same disease, the timing of treatments varied.

The combination treatments of two types of pests as examplified by leaf spot (a disease) and the lygus bug (an insect) indicated that two types of pesticides can be applied effectively if the chemicals are compatible. Fourteen jobs consisting of 323 acres was done for this one type of operation. Copper sulphate, DDT, parathion and copper were the chemicals used (Table 26).

CHAPTER V

CHEMICALS USED AS PESTICIDES

Pesticides are chemicals or mixtures of chemicals intended to be used for controlling, preventing, destroying or repelling pests. The word is synoymous (legally) with "economic poison", and more appropriate because some pesticides are not poisons in the customary sense of being highly toxic to humans. As used in this study, the term includes all insecticides, fungicides, herbicides and defoliants that were applied to agricultural crops and land uses.

Many commercially applied pesticides are dangerous to humans, livestock, and the various forms of plant life at least to some degree. Extreme caution must be used to safeguard against harmful effects from the indescriminate use of pesticides. The State and Federal governments, recognizing this, have developed regulations for applying pesticides which are ridgidly enforced to safeguard the public. The commercial applicators of herbicides are required to pass a written examination and obtain a license for themselves and their equipment. Air men must have special permits to drop any material from their planes. Chemical producers must label the ingredients of the pesticides and give directions for their proper use. Food products going on the consumer market must pass toxicity tests when they have been chemically treated. Some of the more pertinent legal restrictions are included in the appendix under "Public Regulations Concerning Chemical Applications".

In chapter IV, many of the environmental influences affecting the successful use of pesticides were brought out. Another vital fact to consider is the use of the right pesticide for the pest to be controlled. To obtain a better understanding of the various pesticides, it is necessary to know their general types as applied to pests. In his Pesticide Handbook, Dr. Donald Frear of Pennsylvania State University lists and discusses them somewhat as follows:

INSECTICIDES

Stomach Poisons or Protective Insecticides

Insects which eat plants and other types of edible materials can usually be controlled by covering the surface on which they feed or travel with a poisonous substance. These poisons are absorbed through the alimentary tract and hence are called stomach poisons. Since they are usually applied before the insect feeds on the plant surface, they are sometimes called protective insecticides.

Most of the stomach poisons are inorganic chemicals. Familiar examples of this type are lead arsenate, cryalite and sodium floride. Less commonly, chemicals such as arsenic trioxide and sodium arsenate are used in poisoned baits to control such insects as ants and grasshoppers.

Contact Poisons or Eradicant Insecticides

Insects which cannot be controlled by poisoning their food supply (sucking insects such as aphids), often may be killed by direct applications of suitable toxic sprays or dusts. In order to kill insects in this manner, the toxic material must actually contact some part of the insects' body. This may be accomplished in three ways: (1) applying the material directly to the body of the insect; (2) applying the material to the surface on which the insect may walk or crawl (residual treatment); or (3) introducing the toxic material into the air which the insect breathes, which is called fumigation. Examples of chemicals used for direct or contact treatment are nicotine, petroleum oil, pyrethnum and parathion. Residual chemical examples are DDT, chlorodane, methoxychlor and adrin. No fumigants were included in the study.

FUNGICIDES

Two general types of fungicides are usually recognized: protective and eradicant.

Protective Fungicides

The protective fungicide is applied before the disease appears, and serves to kill or inhibit the growth of the fungus when it arrives on the material to be protected. Examples of this fungicide are seen in the extensive use of seed treatments against soil organisms. Chemicals of this type most commonly used are copper compounds, sulphur, organic mercury compounds and a variety of synthetic organic compounds.

Eradicant Fungicides

Eradicant fungicides are less commonly used, but include lime, sulphur, organic mercury, formaldihyde, and dinitro compounds. As the name implies, these are used to "burn out" or eradicate fungi which have already located and are actually growing.

HERBICIDES

Selective Herbicides

Selective herbicides are thos chemicals which will kill certain types of plants (weeds) without serious injury to other desirable types growing in the same areas. Until recent years, only a limited number of selective herbicides were available, and these were not always satisfactory. The discovery of 2,4-D, however has made available an excellent selective herbicide and this compound is now widely used. Various forms and formulations of 2,4-D are now available. They all have the property of killing most broad-leaf plants without injury to grasses, cereals and other monocotyledonous plants. A related compound 2,4,5-T is effective in killing woody plants, trees, shrubs, and brambles. Potassium cyanate, MCP and some organic dinitro compounds are other examples of selective herbicides.

<u>Non-Selective Herbicides</u>

Chemicals of this group are those which destroy all forms of plant life. These are useful in eradicating completely all herbage from crop lands over grown with undesirable species, or from roads, railways and canals. Examples of this type of herbicides are sodium arsenate, sodium chlorate and sulfuric acid.

PESTICIDES APPLIED IN OREGON

In this study pesticides of the various types discussed were applied to 85,788 acres of agricultural crops and land uses. Of this total, 70,704 acres were sprayed in 1,517 jobs, and 15,083 acres were dusted in 407 jobs (Table 27). The chemicals used for the treatment of these acres were also many and varied. Forty-two individual chemical compounds and thirty-eight combinations of two,

Table 27. Summary of all chemicals applied by air and ground: Number of jobs, acres, pound of chemical applied per acre, per acre charges for application and chemical.

Chemical		No. of jobs	Acres treated	Lbs. of chem. applied	Application charges	Chemical charges
			Air			
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-ST)	S	1	15.0	4.0	1.47	8.13
Captan	D	5	62.0	1.9	3.02	----
	S	4	109.0	1.5	2.50	2.48
Total		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	----
	S	8	190.0	----	2.49	----
Total		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

* S - Spraying
** D - Dusting

Table 27. (cont.)

Chemical		No. of jobs	Acres treated	Lbs. of chem. applied	Application charges	Chemical charges
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
	S	359	12,484.5	1.2	1.52	.63
Total		598	18,336.0	1.1	1.66	.65
Copper sulfate, DDT	D	1	50.0	----	2.00	----
	S	5	122.0	----	2.50	----
Total		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	----

Table 27. (cont.)

Chemical		No. of jobs	Acres treated	Lbs. of chem. applied	Application charges	Chemical charges
DDT, Parathion	D	1	17.0	----	$ 3.29	$ ----
	S	18	398.0	----	1.72	1.67
Total		19	415.0	----	1.78	1.67
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
	S	7	106.0	1.0	1.58	2.93
Total		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	----

Table 27. (cont.)

Chemical		No. of jobs	Acres treated	Lbs. of chem. applied	Application charges	Chemical charges
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
	S	2	40.0	.4	2.50	2.67
Total		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	----
	S	50	1,114.5	3.0	1.67	----
Total		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	----
Totals						
D		408	14,736.0	3.6	2.26	.88
S		927	60,330.3	1.1	1.33	.76
Air Sub Total		1,335	75,066.3			

Table 27. (cont.)

Chemical		No. of jobs	Acres treated	Lbs. of chem. applied	Application charges	Chemical charges
			Ground			
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, ATZ	S	8	65.0	---	2.09	6.65
2,4-D, 2,4-DS	S	1	16.0	---	.62	1.00
2,4-D, Polybar	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
ATZ	S	1	2.0	4.8	----	13.60
ATZ, 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
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

Table 27. (cont.)

Chemical		No. of jobs	Acres treated	Lbs. of chem. applied	Application charges	Chemical charges
DDD	D	5	47.0	1.9	$ 1.60	$ 2.90
DDT	D	22	126.0	2.2	1.82	3.71
	S	2	35.0	5.8	3.43	2.11
Total		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 Premerge	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		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
Polybar	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

Table 27. (cont.)

Chemical		No. of jobs	Acres treated	Lbs. of chem. applied	Application charges	Chemical charges
NACl	S	1	20.0	200.0	$ 5.00	$ ----
IPC, Nu Green (fert.)	S	2	91.0	---	2.15	----
Totals						
D		62	347.3			
S		590	10,373.9			
Sub total (ground)		652	10,721.2			
Grand total (ground and air)		1,987	85,787.5			

Chemical charges were included for only those jobs when the applicator furnished the chemical. Where jobs were less than an acre the charges are pro rated.

three or four chemicals were used to control some form of pest. These chemicals were in different formulations (sprays or dusts) and some were available in forms with varying percentages of actual chemical per unit sold. Because the parent acid or active ingredient varied from less than one per cent to one hundred per cent, all of the chemicals had to be reduced to actual weight of the active chemical ingredient itself. It was also necessary to do this in order to get spray and dust weights on the same basis.

Procedure

The chemicals included in this study are considered in much the same way as were crops and pests. This whole section is presented primarily for those interested in the control of pests from the standpoint of the chemicals used for that purpose. Table 27, divided by ground and air applications, lists all chemicals used, either separately or in combinations. For each listing, total acres indicate volume and validity of the sample. The average pounds of a chemical applied per acre, the chemical charge and what the application charge per acre was for each chemical are the important parts of the Table. When a chemical was used both as a spray and as a dust, the above data is presented for each formulation as well as a total or average for both.

The discussion of the chemical is divided into those applied by "air" and those by "ground". For each of these two divisions, the major chemicals used for combatting insects, weeds, disease or for defoliation are presented in tables extracted from Table 27. Upon completion of the discussion of each, a brief comparison is made between the ground and the air applications.

Aerial Applied Pesticides

Nearly 88 per cent (75,066 acres) of the total pesticide work done was from the air (Table 27). The 1,335 treatments (both spray and dust) were with insecticides, herbicides, fungicides and defoliants. Twenty-nine single chemicals and 23 combinations were used for these purposes. The leading chemicals are presented in Table 28 for each type of pest.

Substantially more acres were treated with DDT than with any of the other insecticides. The DDT sample consisted of 18,336 acres treated in 598 jobs (Table 28). The chemical was applied at the average rate of 1.1 pounds of active ingredient per acre with the average charge for application $1.66 and for the chemical $0.65. Malathion, used on 2,702 acres, had an average application rate of 2.0 pounds, an application charge of $2.52 per acre and a chemical charge of $3.32. Toxaphene was the

Table 28. Leading chemicals applied by air: By pest type, number of jobs, total acres, average pounds per acre applied, per acre charges for application and for chemical.*

Chemical	No. of jobs	Total acres treated	Average per acre		
			Lbs. of chem. applied	Application charge	Chemical** charges
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	----
Herbicide					
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
Fungicide					
Sulfur	9	306	40.7	2.50	----
Dithane	5	473	1.0	2.07	----

* These data extracted from Table 27.
** The chemical charges are included only when the applicator furnished them.

other major chemical used.

Aerial application of herbicides was the predominant type of pesticide treatment. Of the eleven herbicides used, the leading weed killer, 2,4-D had more acres (35,126) treated than the rest combined. The average application rate per acre was 0.9 pounds; the application charge, $1.14; and the chemical charge $0.78 per acre. Much of this work was treating wheat in large jobs in Eastern Oregon and because of this volume the charges were quite low. Chloro IPC, a selective grass killer, was applied to nearly 4,000 acres in 39 jobs. The chemical was applied at an average rate of 2.4 pounds per acre and was applied for an average charge of $1.04 (Table 28).

Dinitro general is an herbicide, yet is used as a pre-harvest defoliant. In 27 jobs, 639 acres were treated with an average of 1.4 pounds of active ingredient per acre. The application charge was $2.52 an acre and when the chemical was furnished the average charge for it was $1.48.

Chemical applications to control diseases were limited although fifteen fungicide or combinations were used (Table 27). Several of these combinations included various insecticides as well. The leading fungicide, dithane was applied in five jobs to 473 acres at one pound per acre (Table 28). The average application charge was

$2.07 per acre. Sulfur, the other leading fungicide had 306 acres treated in nine jobs. It was applied at an average rate of $4.07 pounds and at a charge of $2.50 per acre to apply it. These fungicides were both "farmer furnished" so no charge is indicated for the chemical.

The average figures for the chemicals listed in Table 28 show the composite results of all the jobs done with each chemical regardless of the specific pests treated. For the individual pests, these average rates varied considerable.

Ground Applied Pesticides

Pesticides were applied to 10,721 acres with custom ground equipment (Table 27). The treatments consisted of 652 jobs using herbicides primarily; yet including some insecticide, fungicide and defoliant work. Twenty-eight chemicals were used by themselves and sixteen combinations of chemicals were used to control pests. The leading chemicals applied from the ground are presented in Table 29.

Very little insecticide work was done with ground equipment. For that done, eleven insecticides or combinations of insecticides were used (Table 27), DDT, applied at 3.0 pounds per acre, was the most common insect treatment (Table 29). In twenty-four jobs, 162 acres were thus treated. The per acre application charge averaged $2.17

Table 29. Leading chemicals applied by ground: By pest type, number of jobs, total acres, average pounds per acre applied, per acre charges for application and for chemical.*

Chemical	No. of jobs	Total acres treated	Averages per acre: Lbs. of chem. applied	Application charge	Chemical** charges
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 Premerge	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
Fungicide					
Sulfur	8	36	49.0	2.00	3.17

* These data extracted from Table 27.
** The chemical charges are included only when the applicator furnished them.

and the chemical charge $3.36. Aldrin, the other leading insecticide, was applied to 165 acres at an average rate of 3.2 pounds per acre. The application charge was $2.01 per acre and $7.37 was the charge for the chemicals used per acre.

Over ninty per cent of the chemical applied by ground methods were herbicides. The majority of this work was with the selective herbicide 2,4-D. A total of 5,631 acres were treated in 55 jobs. The average charge to apply 0.9 pounds of 2,4-D per acre was $1.55, and for the chemical, $0.89. Dinitro premerge, a pre-planting weed killer, was used to treat 2,424 acres in 55 jobs. The chemical, applied at an average rate of 1.7 pounds per acre, cost $2.32 to apply. The charge for the chemical was $3.07 per acre.

Two defoliants were applied from the ground, namely dinitro general, and sodium arsenate. The first was applied at 1.4 pounds per acre to 441 acres in 38 jobs. The application charge was $4.01 and the chemical charge, $4.88 an acre. Sodium arsenate, used on 139 acres was put on at the rate of 4.0 pounds. The charge for this was $2.51 and for the chemical, $1.10.

Fungicide applications from the ground consisted of using sulfur to treat 36 acres. Forty-nine pounds of the chemical was applied for an average charge of $2.00 an acre. The charge for the chemical was $3.17 on the average.

As was the case with our application data, the figures presented for the ground work are averages of all the work done with each specific chemical. The range for the actual individual jobs done varied considerably depending on the type of pest to be controlled.

Comparisons of Ground and Air Applied Chemicals

The farmer has two alternatives if he wants to have lands commercially treated with chemicals. He can have it done by ground custom operators or have the "airmen" do it. Quite naturally, then, it follows that he would be interested in seeing the comparison of the rates of application and the charges for the chemical and its application using both methods. A meaningful comparison of this type can be made only when a substantial sample of each is available. Table 30 lists comparative data for the major chemical of each type, that is, an insecticide, an herbicide, a defoliant and a fungicide.

Several things are apparent from Table 30. For three of the leading chemicals, 2,4-D, dinitro general and sulfur, the number of treatments (jobs) was reasonable equal although substantially more acreage was treated by air methods than by ground. DDT, on the other hand had few treatments or acres covered by ground equipment. Yet over 18,000 acres were treated from the air. Furthermore,

Table 30. Comparison of leading chemicals applied by ground and air: Number of jobs, acres, pounds of chemical applied per acre and the per acre application charge.

Chemical	Method of application	No. of jobs	Total acres treated	Averages per acre: Lbs. of chem. applied	Averages per acre: Charge for* application
DDT	Ground	24	162	3.0	$ 2.17
	Air	598	18,336	1.1	1.66
2,4-D	Ground	343	5,631	.9	1.55
	Air	259	35,126	.9	1.14
Dinitro General	Ground	38	441	1.4	4.01
	Air	27	639	1.4	2.52
Sulfur	Ground	8	36	49.0	2.00
	Air	9	306	40.7	2.50

* Does not include chemical charge.

that which was put on from the ground was applied at a rate nearly three times greater than air applications. One of the reasons for this was probably the type of pest controlled from the ground required more of the chemical to effect adequate control.

Except for sulfur applications, the charges for applying the chemicals were markedly higher when done by the ground custom operators. One of the reasons why sulfur applications were more expensive from the air might be the additional weight the planes must carry. Obviously the more weight or volume of chemical the plane must carry, the fewer the acres that can be treated per flight. This necessitates more handling (labor), time and more flights to treat a given acreage.

To understand the reason for the different charges made for the two methods of application, the nature of the two businesses should be noted. Commercial air applications operate on a very "extensive" scale. They are primarily concerned with large acreages over a wide area. The usual job size is large, the 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, the per acre cost is low and subsequently the charge to the farmer is also low.

The ground custom business has quite a different set of circumstances. The jobs are small as a rule, with many being spot spraying, lawn work, or orchard work, all of which cannot be done effectively from the air. The expanding use of the helicopter is "moving in" on the orchard applications however. Many times the ground rigs must be loaded or unloaded in moving to different jobs and the travel time between jobs is considerable. All of these factors increase the cost to the applicator so he must charge more per acre for the treatments made.

To emphasize the characteristic difference between "air" and "ground" charges for custom applications attention is called to Table 31 and to Figure 2. The data clearly indicates the influence of size of job on the charge per acre for application. As already mentioned this results not only in consistantly higher rates for ground work, but also, decreasing charges for both "air" and "ground" as the size of the job increases.

One of the most significant differences between the two methods of application is that the aerial applicators usually do not "sell" the chemical but only the service of applying it. As was shown in Table 27, the charges were quite low on those chemicals they did furnish. It is their general opinion that the small profit made from selling chemicals, when large amounts are used, does not pay for the additional work of buying, handling and

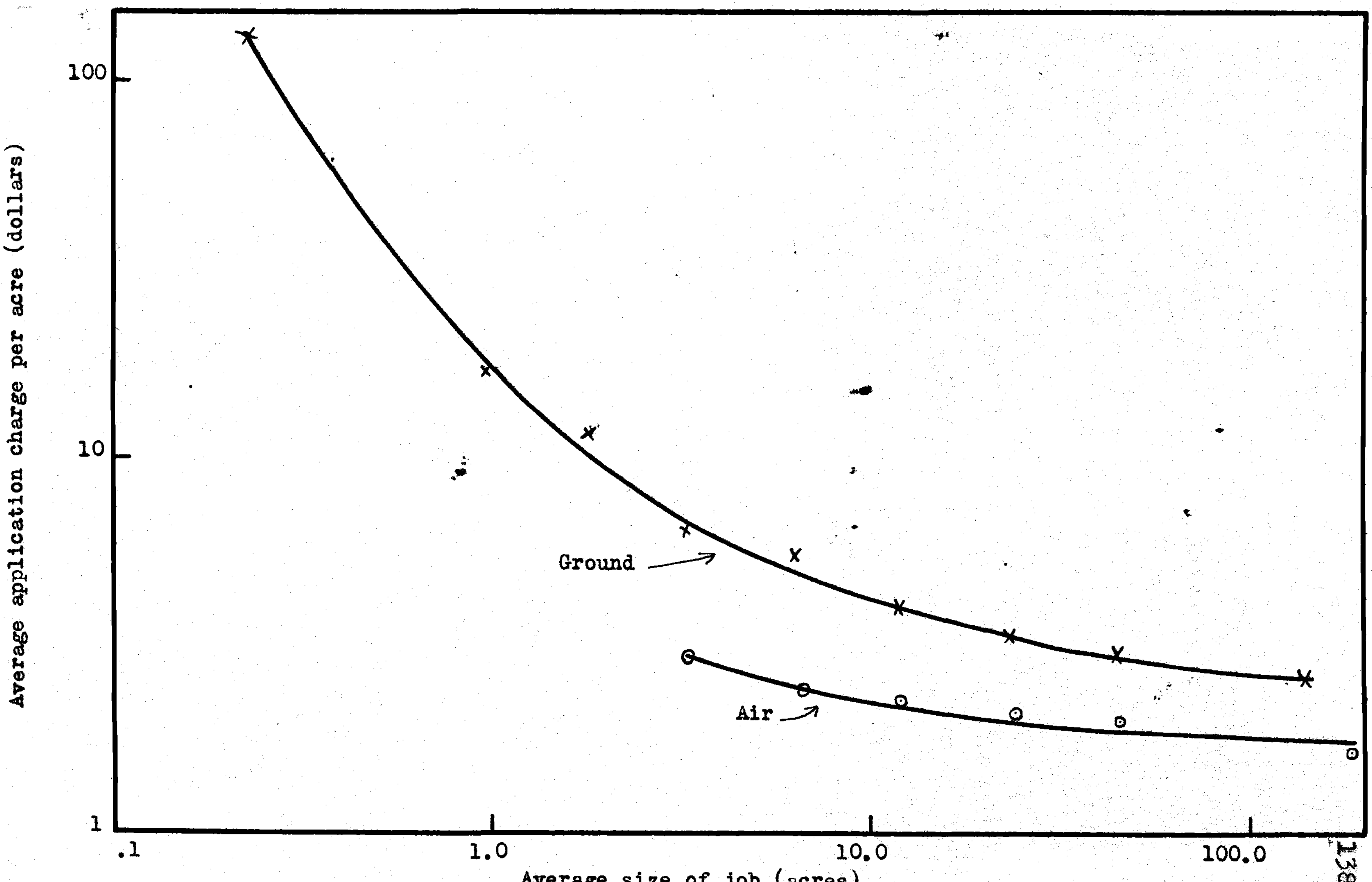

Figure 2. Application Charges As Related To Size Of Job

Table 31. Ground and air application charges as related to size of job: Number of jobs, total acres, average job size and average application charge per acre.

Size of job (acres)	No. of jobs	Total acres	Average job size	Average charge* per acre
		Ground application		
0.0- 1.00	50	28.6	.57	$ 41.85
1.0- 3.99	123	337.4	2.74	7.41
4.0- 7.99	155	981.8	6.33	5.50
8.0-15.99	176	2,092.2	11.89	3.99
16.0-31.99	104	2,395.0	23.03	3.35
32.0-63.99	46	2,081.4	45.25	3.00
64.0 and up	25	3,485.2	139.41	2.92
Ground Total	679	11,401.6	16.79	$ 3.68
		Air application		
1.0- 3.99	64	214.0	3.34	$ 3.05
4.0- 7.99	126	837.0	6.64	2.38
8.0-15.99	303	3,678.8	12.14	2.28
16.0-31.99	382	9,126.0	23.89	2.10
32.0-63.99	327	14,894.5	45.55	2.00
64.0 and up	371	68,397.5	184.36	1.65
Air Total	1,573	97,147.8	61.76	$ 1.78

* Does not include charge for chemical.

reselling it. The ground operator, however, usually makes part of his money from both the application and the chemical. When small jobs are done, the farmer would usually prefer to pay extra for the chemical and not have to worry about obtaining it. He (the farmer) is actually paying the ground operator for his technical "know-how" in obtaining the correct form and amount of the required chemical and applying it. He often pays this through the increased price of the pesticide.

CHAPTER VI

FERTILIZER APPLICATION IN OREGON

In the preceding chapters, the primary concern has been the application of insecticides, herbicides, defoliants and fungicides. Commercial fertilizer applications also represented a significant part of some of the custom operators' businesses. For this reason, consideration will be given to some important aspects involved in the application of fertilizer. Table 32 is a comparison of the amount of fertilizer work done with the total custom applications included in the study.

Over 22,000 acres or 20.5% of the total commercial work was with the application of fertilizers. The 252 jobs represented 11.2 per cent of the total jobs done and the average size of job was nearly twice that of the chemical treatments.

There was very little fertilizing done from the ground. The extent was 27 jobs involving 680 acres. For this reason, in the following discussion it is assumed that fertilizers were all applied from the air.

Table 32. Summary of comparison of fertilizer applications with the total commercial work reported in the study.

Operation	No. of jobs*	Total acres*	Average job size	Average charge per job	Average charge per acre for application	Total application charges
Fertilizer	253	22,220	87.8	131.00	$ 1.49	33,156.00
Total sample	2,253	108,549	48.2	75.00	1.56	168,978.00
% of Total	11.2%	20.5%	----	----	----	19.6%

* These totals include jobs where fertilizer was applied in combination with some other operation.

ADVANTAGES OF AERIAL FERTILIZING

Soil and Crop Vulnerability

The preponderance of work was done by aerial equipment because of several advantages not enjoyed by ground operators. Most fertilizer applications were made early in the spring. At this time, the plants are just commencing a period of rapid growth and development and require large quantities of plant nutrients. Also there is usually an abundance of moisture and an anticipation of more precipitation later in the season. This insures the crop maximum opportunity to get the full benefit from the fertilizer. A limiting companion feature of this period of time is the vulnerability of the soil (and the crop) to excessive "cutting up" or the other extreme, compaction, by ground equipment moving over it. While the soil condition may be such that ground rigs cannot function, air applicators obviously do not have this problem. If the crop needs to be fertilized, they do so without regard to soil condition. The farmer gains, two ways: (1) by getting the fertilizer to the crop when it can do the most good, and (2) by not damaging the crop or soil or both when they are vulnerable.

Isolated Areas

Areas maybe inexcessible to ground equipment not only because of soil conditions, but also physical barriers such as topography, or sheer distance from the home base area. An example of the latter might be the mountain meadows in parts of Eastern Oregon. Many of these meadows respond favorably to the use of fertilizer, yet because of distances and other terraine difficulties, ground equipment cannot be used economically. Again, air equipment, with its complete independence of ground conditions and its wide range of distance possibilities has a distinct advantage.

Jobs can be done quickly from the "air". The later the season gets, the more important this becomes, as the difference of a few days may markedly affect the benefits derived from the use of fertilizer. If the farmer relies on his own equipment, the fertilizing operation may represent an additional operation on a crop and compete directly with his other spring work for the use of time, labor and equipment. The aerial applicator can do in hours what the farmer might need days to do, and not interfere with other farm work either.

Aerial Application Less Expensive

Commercial air application of fertilizers was relatively inexpensive when compared to the per acre charges of ground applicators in this study. For the air, the average application charge was $1.49 per acre, and for the ground, it was $2.43 (Table 11). Depending on the circumstances, there could be a substantial saving to the farmer if he hired the work done by airmen. The difference in these charges can be explained in several ways. As was mentioned in the chemical section, Chapter V, the size of the jobs is an important factor. Air operators depend on a large volume of business which can be done in a short time. By doing big jobs, and having a central base to get the fertilizers from, they reduce the time and labor required to treat each acre. With lower per acre costs, they can reduce their charges for the application. Ground applicators must haul equipment and fertilizers from one area to another and must load and unload these things many times. The time required to treat each acre is greater by ground, as is also the moving time from one job to the next. With greater amounts of labor involved and less treated acres, the custom ground men must charge more to meet operating expenses.

Aerial applicators often seek fertilizer work as a seasonal "fill in" when chemicals are not being applied. For the pesticide work, many of the planes are equipped for either spraying or dusting. With the dusting equipment fertilizers can also be applied. With the equipment already available, and without additional expense, they can keep their labor and equipment busy during the slack seasons.

Fertilizer work is also done as a means of obtaining the farmers' business later in the season when chemical controls are needed. He may do the work at a greatly reduced charge per acre in order to accomplish this. The ground applicator because of his limited scope of operation and additional equipment requirements cannot compete economically for chemical business by this same means.

CROPS TO WHICH FERTILIZERS WERE APPLIED

The results of the fertilizer sample show 22 different crops or land uses thus treated. Table 33 gives a complete summary of all fertilizer work included in the study.

The twenty-two categories represented, actually included several minor varieties of crops or uses. An example of this is "other grains" which contained cereals such as buckwheat, emmer, millet or spelts. For most of these categories, more than one kind of fertilizer was applied and at varying amounts and charges (Table 33).

Application Charges

For the application of all types of fertilizers there was a wide range in the per acre charges. The lowest average charge was $0.90 per acre for applying ammonium phosphate to 20 acres of strawberries. The highest

Table 33. Summary of the kinds of fertilizers applied by crops: Number of jobs, acres, total pounds of fertilizer applied, average application charge per acre.

Crop	Fertilizer	No. of jobs	Total acres	Total pounds fertilizer applied	Averages per acre: Pounds applied	Averages per acre: Application charge
Barley	Amm. Phos.	1	37.0	8,240	223	$ 2.45
	(urea)	1	45.0	2,320	52	1.24
	Total	2	82.0	10,560	---	1.80
Oats	Amm. Nit.	1	7.5	960	128	1.47
Wheat	Amm. Nit.	30	7,564.0	522,040	69	.95
	(urea)	3	36.0	3,140	87	1.25
	Anhydrous Amm.	1	262.0	18,000	69	1.00
	Total	34	7,862.0	543,180	---	.95
Grain mixtures	Amm. Nit.	3	113.5	10,400	92	1.50
	Nu-Green	1	265.0	27,000	102	1.00
	Total	4	378.5	37,400	---	1.15
Other grains	Amm. Phos.	1	40.0	4,960	124	1.25
	Amm. Nit.	2	41.0	3,440	84	1.60
	Total	3	81.0	8,400	---	1.43

Table 33. (cont.)

Crop	Fertilizer	No. of jobs	Total acres	Total pounds fertilizer applied	Averages per acre	
					Pounds applied	Application charge
Alfalfa	Amm. Nit. and Amm. Sulph.	1	9.0	1,520	169	$ 2.22
Clover	Amm. Sulph.	1	22.0	3,040	138	1.64
	Amm. Nit.	1	37.0	3,700	100	1.51
	Superphosphate-Boron	1	11.5	2,460	214	2.35
	Lime	1	100.0	15,700	157	1.57
	Total	4	170.5	24,900	---	1.62
Vetch	Land plaster	1	50.0	5,000	100	1.24
Bluegrass	Urea	4	87.0	8,320	96	1.49
Fescue	Amm. Phos.	1	47.0	5,920	226	1.51
	Amm. Sulph. and Amm. Nit.	1	160.0	16,640	104	1.04
	Amm. Sulph.	3	403.0	49,400	122	1.49
	Total	5	610.0	71,960	---	1.37

Table 33. (cont.)

Crop	Fertilizer	No. of jobs	Total acres	Total pounds fertilizer applied	Averages per acre: Pounds applied	Averages per acre: Application charge
Ryegrass	Amm. Phos.	4	745.0	145,280	195	$ 1.95
	Amm. Phos. - Nit.	1	57.0	7,680	135	1.60
	Urea	2	126.0	20,160	160	1.85
	Amm. Sulph.	76	5,290.5	982,570	186	2.07
	Amm. Sulph. - Amm. Nit.	2	218.0	26,940	124	1.49
	Amm. Sulph. - Urea	15	1,109.0	174,429	157	1.82
	Amm. Nit.	21	1,493.0	168,960	113	1.32
	Amm. Nit. - Cal. Nit.	1	70.0	8,480	121	1.46
	Urea	12	1,123.0	134,800	120	1.63
	Uran	2	136.0	2,478	182	1.50
	Superphosphate	1	79.0	19,200	243	2.43
	Total	138	10,698.5	1,735,257	---	1.86
Other grasses	Amm. Nit.	1	142.0	29,200	206	2.57
	Urea	1	8.0	960	120	1.50
	Total	2	150.0	30,160	---	2.51
Pastures	Amm. Phos.	1	40.0	6,000	150	1.71
	Amm. Nit.	4	161.0	16,720	104	1.35
	Urea	1	10.0	1,040	104	1.30
	Total	6	211.0	23,760	---	1.43

Table 33. (cont.)

Crop	Fertilizer	No. of jobs	Total acres	Total pounds fertilizer applied	Averages per acre: Pounds applied	Averages per acre: Application charge
Summer fallow (idle land)	Amm. Sulph	1	24.0	2,400	100	$ 1.25
	Amm. Nit.	3	722.0	72,220	100	1.03
	Urea	1	20.0	2,000	100	1.25
	Sulphate of Potash	1	5.0	682	136	3.60
	Total	6	771.0	77,302	---	1.06
Pepper Mint	Urea	2	48.0	5,440	113	1.60
Tree fruits (Other)	Amm. Nit.	1	14.0	2,000	143	1.71
Filberts and Hazelnuts	Amm. Nit.	1	4.5	800	178	2.44
Strawberries	Amm. Phos.	1	20.0	400	20	.90
	Urea	23	656.4	31,352	28	2.40
	Urea - IPC	2	91.1	---	---	2.15
	Nitrogen Solution	1	10.0	111	11	3.00
	Total	27	795.5	31,863	---	2.39
Beans	Amm. Nit.	2	40.0	6,000	150	2.07
	Boron	1	12.0	500	42	1.50
	Total	3	52.0	6,500	---	1.94

Table 33. (cont.)

Crop	Fertilizer	No. of jobs	Total acres	Total pounds fertilizer applied	Averages per acre	
					Pounds applied	Application charge
Beets	Amm. Nit.	1	10.0	2,000	200	$ 2.20
	Boron	1	113.0	2,500	221	1.00
	Total	2	123.0	4,500	----	1.10
Potatoes	Urea	2	23.5	2,380	101	*
	Uran	1	7.5	83	11	2.93
	Total	3	31.0	2,463	----	.97
Other uses	Urea	1	10.0	----	----	2.00
	Amm. Nit.	1	10.0	1,600	160	1.80
Grand Total or Average	Fertilizer	253	22,220.0	2,634,885	118	$ 1.49

* No charge was made on 20 acres of this job.

charge, $3.60 per acre, was for applying sulphate of potash to five acres of idle land. The charges varied with the type of fertilizer and the amount (weight) applied per acre.

Major Crops

Applications to five crops or land uses constituted 93 per cent of the fertilizer work done in the sample. They were ryegrass, wheat, summer fallow, strawberries and fescue. The major crops fertilized are shown in Table 34.

Nearly half (10,698 acres) of the total fertilizer application were made on ryegrass. This was done in 138 jobs and with an average job size of 77.5 acres. Wheat and summer fallow were the other major categories treated and this acreage came primarily from Central and Eastern Oregon. Large acreages per job, and light applications of fertilizer and low per acre charges were the rule. Except for the above wheat acreages nearly all of the fertilizer work was done in the Willamette Valley and at a substantially higher charge per acre.

As can be seen in Table 34, when the average size of jobs get smaller, the charge per acre went up and vice versa. Wheat had an average of 231.2 acres per job and an application charge of $0.95 per acre. For strawberries these figures were 28.1 acres per job and a $2.39 charge.

Table 34. Extent to which leading crops were fertilized: Number of jobs, acres, average size of job and average application charge per acre.

Leading crops	No. of jobs	Acres	Average size of jobs (acres)	Average application charge (per acre)
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

The general relationship between size of job and application charge per acre is shown in Table 31 and Figure 2. It should be remembered, however, that average job size is only one reason for changing charges for application. The type of fertilizer and its rate of application were also influential.

Major Fertilizer

Twelve different fertilizers were applied to the crops and land uses in the samples. These were applied both individually and in combinations. Over two million pounds of ammonium sulphate, ammonium nitrate, and urea were applied to 19,000 acres in 208 jobs constituting the majority of fertilizer work. Ammonium sulphate was used primarily on ryegrass, ammonium nitrate on ryegrass and wheat, and urea on strawberries.

The number of pounds of fertilizer applied varied greatly between fertilizers and within the same fertilizer. Ammonium sulphate had a range of from 83 pound to 303 pounds applied per acre while its average rate was 180.6 pounds. Table 35 shows this information for the three leading fertilizers.

As was previously mentioned, the rates of application are important in determining the per acre charges. Most aerial applicators charge either completely or partially

Table 35. Summary of leading fertilizers: Number of jobs, acres, total pounds applied, average pounds applied per acre and range.

Fertilizer	No. of jobs	Acres	Total pounds applied	Average pounds applied per acre	Range in pounds per acre
Ammonium Sulphate	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	----	----

by the pound of fertilizer which must be transported and applied per acre. Two examples are cited. One airman has a low flying charge of $1.25 per acre which includes applying all fertilizer up to the rate of 100 pounds per acre. For each additional pound a cent is charged. For applying 150 pounds per acre, the charge would be $1.75 under this system. Another applicator charges a flat rate of a cent or two a pound regardless of the pounds per acre applied. Under this system application charges in the example given would be either $1.50 or $3.00 per acre depending on the per pound charge.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Estimated Losses From Pests

In recent years, losses to American agriculture of five, four and three billions of dollars annually are estimated to have been caused by weeds, insects and diseases respectively. Oregons' share in these losses is currently estimated to be 50, 40, and 26 million dollars, respectively, for each of the pest types. The losses come about in several ways: namely, competition with a crop for available plant nutrients and moisture; attacks on the structure of the plant or its produce thus killing the plant or reducing yields; and contamination of the product, thus requiring additional handling and sorting to obtain a saleable product. Some indirect losses include watershed destruction, soil erosion, esthetic value losses in recreation areas, and forage losses to livestock and game.

Development of Pesticides.

Increased intensification of agriculture, with the subsequent increase in pests, emphasized the fact that mechanical and chemical control measure being used previous to the second world war were rapidly becoming inadequate. This situation was changed, however, with the discovery of 2,4-D, a selective herbicide, and DDT, an insecticide. These two and many more diverse and comples chemicals, which have been developed since 1945 have enabled the farmer to effect an economic control for nearly every pest in the crops he grows. Without doubt, the rapid development and use of chemicals in farming has been one of the major advances in the field of technical agriculture.

Increase In Commercial Pesticide Applicators

The increase in the complexity of chemicals and their specific uses has led to the development of pesticide specialists. The trend now is for the farmer to hire commercial applicators to do the pesticide work. Because chemical controls have only recently assumed their important position, very little information is available concerning their overall use. This study of commercial applicators was made in order to find out such related things as the crop treated, the pest attacked, the kind and amount of chemical used, and the customary charge for its application.

Procedure Followed in Study

In 1956, a practical worksheet, designed to contain all the necessary information needed for the commercial application business and for the College Study, was developed. The cooperating custom operators filled these out and periodically sent them to the College. To tabulate the data, code lists were developed for the operators, counties, insects, diseases, weeds, crops, chemicals and fertilizers. That is, a separate number was given to each operator, each county, etc. The data were then tabulated and later summarized with the help of IBM equipment.

General Findings

A total of 108,549 acres of land in Oregon was commercially treated by the cooperating applicators. Included in the total are 15,083 acres that were dusted; 70,603 that were sprayed, 21,924 that were fertilized and 939 acres that had "other" work done.

The average charge for these applications, not including the chemical, was $1.56 per acre. It is significant that spray work was far more important than dust. The main reasons for this were that sprays are cheaper to apply, can be put on in windy weather, and have a longer residual effect than dust. The average per acre charge for dusting was $2.28 and for spraying, $1.42.

Of the total acres treated, 97,147 were air applications and 11,402 ground treatments. Air treatments were cheaper than those made from the ground. The average charge per acre was $2.04 for "ground" as compared to $1.50 for "air".

The State Department of Agriculture estimated 573,574 acres were commercially treated in Oregon in 1956. The study sample (108,549 acres) constituted 18.9 per cent of this total. The commercially treated acres were located in four of the six major agricultural areas in Oregon. These were the Willamette Valley, Columbia Basin, Central Oregon and the Snake River Basin. In Oregon, twenty of the thirty-six counties were represented. Counties with the leading acreage treated for weeds were Sherman, Umatilla and Jefferson; for insects, Jefferson, Yamhill and Benton; for disease, Yamhill, Marian and Lane. The major fertilizer work was done in Linn, Umatilla and Benton counties.

Pest Control

The best of pesticides may fail if used at the wrong time or in the wrong way. There are many factors which influence the successful control of pests. Such things as correct identification of pests, knowledge of their life cycles, properties of the chemicals used as pesticides, and the influence of environmental factors are all important for the custom man to consider.

Chemicals were applied for pest control in 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 fifty combinations, and six separate diseases. Six combinations of the above jobs were also included.

Chemicals Used

For pest control, forty-two individual chemicals and 38 combinations of two, three and four chemicals were used. The chemical 2,4-D (a weed killer) was easily the most important. It was used to treat 40,757 acres in 602 jobs of primarily air work.

Charges for chemicals varied with the kind used, the method of application and the individual applicators. Most of the materials used by air operators were farmer furnished. The rest was charged for at about the list price of the chemical. Ground operators, on the other hand, did smaller jobs and tended to charge somewhat higher rates for chemicals than did the airmen.

Two significant things can be noted about the application charges for pesticides: (1) as the job sizes got larger for both "air" and "ground", the charges per acre tended to decrease, and (2) for every job size the average aerial charge per acre for application was markedly less than for ground operations.

Fertilizers Included

Fertilizer applications, while not an integral part of the chemical study, represented an important part of some of the custom operators' businesses. There were 22,000 acres of fertilizer work done. This was 20.5 per cent of the total acreage reported in the study. It was almost entirely done by air. The airplane has the advantages of being able to apply fertilizers when soil conditions and growing crops are vulnearable; when the land is isolated and difficult to reach by ground; and when the saving of time 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 farmers chemical business later in the season.

Twenty-two crops or land uses had fertilizers applied to them with ryegrass, wheat, summer fallow and strawberries receiving the heaviest application. Twelve different fertilizers were used, yet ammonium sulphate, ammonium nitrate and urea were the only ones of importance. Over two million pounds of these three were applied. Ammonium sulphate alone accounted for one million pounds.

Economics of Pest Control

The use of pesticides on crops is of little value to the farmer unless they can be applied economically. To get a clear picture of the relative costs of pesticide applications for ten crops, the number of pounds of produce required to pay for the chemical and its application on selected pests was computed. In every case, when compared with normal yields of the crops, very few pounds of produce were estimated to be required to pay for the pest control measures.

The net financial return to the farmer as a result of chemical control practices is difficult to estimate, yet it may mean the difference between a saleable product and a partial or complete loss. Insect damage is the best example of this. If the cherry fruit fly is not controlled the wormy crop cannot be marketed commercially--yet, on the basis of this study as little as three and one-half pounds of cherries per tree (assuming fifty trees per acre) will pay for the total cost of the chemical and the three applications usually necessary for its control. An example of the financial reward as a result of weed control in wheat is the increase in yield by controlling tarweed and mustard. Based on the findings of the study, the chemical and its application can be paid for with less than a bushel of grain to the acre. Experimental data shows, however, than an average increase of four bushels of wheat per acre can be expected.

For the ten crops used as typical examples, cost of control of the major pests was very 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 the charges found in this study, it is believed that the great majority of control measures here studied would more than pay for themselves under average conditions.

BIBLIOGRAPHY

1. Ahlgren, Gilbert H., Glenn C. Klingman and Dale E. Wolf. Principles of weed control. New York, Wiley, 1951. 368p.

2. Brotell, Albert P., Paul E. Strickler and Harold C. Phillips. Extent and cost of spraying and dusting on farms--1952. Washington, D. C., U. S. Government Printing Office, 1955. 25p. (U. S. Dept. of Agriculture. Statistical Bulletin, No. 156.)

3. Chamber of Commerce of the U. S. of America. Agricultural service department committee. A suggested program of weed research and control. Washington, D. C., 1930. 31 unnumbered leaves. (Mimeographed)

4. Frear, Donald E. H. Types of pesticides and general uses. In: Pesticide Handbook. State College, Pennsylvania, College Science Publishers, 1955. p.6-7.

5. Freed, Virgil H. Factors influencing the success of pesticide applications. In: the Oregon agricultural chemical applicators' manual. Salem, Oregon, State Dept. of Agriculture, Division of Plant Industry, 1956. p.126-137.

6. ________________. The loss due to weeds in Oregon. In: Report on weed project 41. Corvallis, Oregon State College, Feb. 1, 1954. p.911-919. (unpublished)

7. Gunderson, Harold. Pesticides are improving. Better Farming Methods 29(1):26-29. January 1957.

8. Haenssler, G. J. Losses caused by insects. In: U. S. Dept of Agriculture. Insects: the Yearbook of Agriculture, 1952. Washington, D. C., U. S. Government Printing Office, 1952. pp.141-147.

9. Messenger, K., and W. L. Papham. From 0 to 5000 in 34 years. In: U. S. Dept. of Agriculture. Insects; the Yearbook of Agriculture, 1952. Washington, D. C., U. S. Government Printing Office, 1952. pp.250-252.

10. Oregon State Dept. of Agriculture. The Oregon herbicide applicators' law. In: the Oregon agricultural chemical applicators' manual. Salem, Oregon, State Dept. of agriculture, Division of Plant Industry, 1956. pp.5-8.

11. Oregon State College. Dept of Entomology. Types of insecticide formulations. Corvallis, 1954. (County Agents Field Manual)

12. Robbins, Wilfred W., Alden S. Crafts and Richard N. Raynor. Weed control. 2d ed. New York, McGraw-Hill, 1952. 503p.

13. Sullivan, Ralph R., and Robin E. Moser. Toxicity and public health aspects of pesticides. In: the Oregon agricultural chemical applicators' manual. Salem, Oregon, State Dept. of Agriculture, Division of Plant Industry, 1956. pp.17-26.

14. Terriere, L. C., and Virgil H. Freed. Formulation. In: the Oregon agricultural chemical applicators' manual. Salem, Oregon, State Dept. of Agriculture, Division of Plant Industry, 1956. pp.121-125.

15. United States Department of Agriculture. Agricultural Marketing Service. The farm income situation. Washington, D. C., U. S. Government Printing Office, April 24, 1956. 8p.

16. United States Department of Agriculture. Agricultural Marketing Service. The farm income situation. Washington, D. C., U. S. Government Printing Office, September 17, 1956. 71p.

17. Wood, Jessie I. Three billion dollars a year. In: U. S. Dept. of Agriculture. Plant Diseases; the Yearbook of Agriculture, 1953. Washington, D. C., U. S. Government Printing Office, 1953. pp.1-10.

APPENDIX

APPENDIX

PUBLIC REGULATION OF CHEMICAL APPLICATIONS

Introduction

Chemicals are used for pest control because they are toxic to, and effectively destroy certain undesirable forms of life. Many of these materials are also poisonous to man and domestic animals. When the various pesticides are applied there is a considerable difference in the period in which they are actually effective in controlling pests. Some chemicals such as TEPP, an organic phosphate, break down and have no toxicity after 24 hours. Others continue to be effective for a period of months and even years. A natural consequence of many chemical control methods is that parts of the treated crops may contain traces of chemicals, known as residues, when the crops are harvested and processed for human or animal consumption.

Residues can be harmful in two main ways: (1) as contaminants of food they endanger the health of the consumer. In large amounts they can produce rapid and serious reactions. In smaller amounts they may be chronic poisons, which gradually effect the consumer until eventually they influence his health, and (2) as contaminants of animal feed they may affect the health of the animals, either acutely or chronically, or they may be deposited in certain tissues or organs which are later consumed by man.

The Federal Food, Drug and Cosmetic Act

The government, in passing the Federal Food, Drug and Cosmetic Act of June 25, 1938 recognized that the use of pesticides is necessary both to bring many agricultural food crops to maturity in a condition suitable for human consumption and to protect many foods against insect depredation during manufacturing and storage. They further realized that by and large, pesticides are poisons, their toxicity varying only in degree. The terms of the law did not preclude the use of insecticides, but they made provisions which guarantee that when used, the health of the consumer eating foods so treated would be protected.

The Miller Amendment

The most recent effort in Public Law 518 commonly referred to as the Miller Amendment. This law has set up tolerances for all pesticides in an effort to control the amount of residue to which the consumer is exposed. Under the law, food shipments bearing residues above the established tolerances will be contraband and subject to seizure as adulterated.

When the Miller bill went into effect on 22 July

1954, many observers felt it would bring disaster to the pesticide industry; yet to date, it has caused no noticeable cut back in the production of new insecticides. The Food and Drug Administration announced recently that more than 1,250 individual tolerances have been established. This would indicate that there are accurate analytical means of determining pesticide residue on crops, and that extensive research has been done to establish what level of toxicity would be harmful to the consumer. The tolerance established has a wide safety factor; that is, it would take about 100 times the maximum residue permitted by this law to cause injury to humans.

The producer is the most susceptible to losses if his products are seized for excessive residues. For him it represents a direct monitary loss. The commercial chemical applicator, while not directly concerned with the farmers loss, must depend on the farmers patronage in order to continue in business. It is obviously a good practice for the applicator to do all he can to help farmers comply with the law.

Oregon Economic Poison Law

In complying with the Miller Amendment, the most important advice given to pesticide users is to read, understand, and follow the directions on the label. In accordance with the Oregon Economic Poison Law, all pesticide materials are registered; ingredients are labeled and adequate directions for its safe use on the specific crops are included. If these directions are followed, there is little chance that excessive residues will remain upon the product.

TYPES OF PESTICIDAL FORMULATIONS

Few pesticides are suitable for use in their pure state. There are many reasons why this is true. Some chemicals may be waxy solids, or oily liquids, unsoluble in water, or in some way not readily useable in normal chemical applicating equipment. Chermicals may be so toxic that they can not be applied in small enough amounts to control the pest without excessive waste or undue hazard both to the handler and to the surface to which it is applied. It is usually not economical to apply most pesticides in concentrated form. To secure coverage over a wider area most materials are deluted before use. To overcome these undesirable characteristics and put the chemical in its most desirable form is the job of the chemists and formulators.

For use in agriculture, pesticides are prepared in four different types of formulations, dusts, granulars, wettable powders and emulsifiable concentrates. In nearly every case the technical grade pesticide which is the basic toxic agent in its commercial form is already mixed with a carrier into one of the four formulations before it is available for commercial use.

Dusts

Dusts as the name implies are finely pulverized materials varying in their content of active ingredient from less than one per cent up to ten per cent or more, depending upon the pesticidal activity of the actual chemical. These materials are usually low in cost, easy to apply and non-staining. A wider swath can be taken by a duster than by a spray rig. Because no mixing with water or oil is required there is a saving in time and labor. Dusts are quite susceptible to wind currents and are more apt to drift. Their resistance to wind and rain is usually low so their residual life is less than that of wettable powders and emulsifiables.

Granulars

A recent development in the chemical field is the formulation of pesticides into large particle size for direct application to the soil. These granulars are similar in concentration to dusts, yet because of their size, granulars do not drift, and do not stick to foliage.

Wettable Powders

Wettable powders are essentially the same type of formulation as a dust, except that they contain a wetting agent which facilitates mixing the dry matter with water to form a suspension rather than a solution. Wettable powders have the physical properties important in application, of uniformity of distribution, particle size, wettability, and suspendability. They are not as susceptible to drift as are dusts, and are more resistant to weathering.

<u>Emulsifiable Concentrates</u>

The fourth type of formulation is designed for mixing with water to form a fairly stable suspension of toxicant. This requires a special emulsifying agent to stabilize the solution and to keep the various chemical components from reuniting. Emulsions are used for most of the residual spraying work done. They must not be applied where humans and domestic animals can come into direct contact with them as the poison ingredient will be absorbed through the skin. They also have a greater tendency towards phyto-toxicity, probably because of the presence of the solvent used to make the original emulsifiable concentrate.

Air ☐ Ground ☐

ORDER **Nº 21**

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		ACRES DONE	MATERIAL USED (gal. or lbs.)	WIND		TEMP.	RATES PER ACRE					
										CHEMICAL		OIL	H2O	WET AGENT	
			A.M.	P.M.			DIR.	VEL.		ACT. INGREDIENT	LBS.	GAL.	GAL.	YES	NO

NORTH ⬆

APPLICATION: Date________ Acres________ @ $____ per acre .... $________

CHEMICAL: Brand________ Amount________ lbs. gal. @ $____; Oil or Wet Agent________ gal. @ $____ ________

Signature________________ TOTAL AMOUNT DUE ... $________

Figure 3.

CHEMICAL APPLICATION PROJECT 1956

WEEDS

Code No.		Code No.	
151	Alder	163	Plantain
111	Annual Bluegrass	118	Poison Oak
148	Big Leaf Maple	136	Puncture Vine
161	Brush	137	Purslane
108	Canada Thistle	132	Quackgrass
124	Cattails	121	Rabbitbrush
112	Cheatgrass	162	Radish
127	Chickweed	143	Rat Tail Fescue
116	Crabgrass	138	Russian Knapweed
128	Dandelion	104	Russian Thistle
180	Defoliation	115	Rye Grass
129	Dock	120	Sagebrush
114	Dodder	130	St. John's Wort
166	Fan Weed	150	Salmonberry
103	Filaree	131	Scotch Broom
106	French Pink	129	Sheep Sorrel
109	Garlic or Onions	145	Speedwell
130	Goatweed	165	Sunflower
133	Gorse	125	Tansy Ragwort
160	Grass	101	Tarweed
113	Groundsel	117	Tussock
122	Halogeton	144	Velvetgrass
134	Hemlock	105	Vetch
152	Knotweed	149	Vine Maple
110	Lambs Quarter	153	Weeds (unnamed)
123	Larkspur	126	White Top
139	Leafy Spurge	119	Wild Blackberry
107	Morning Glory	141	Wild Oats
102	Mustard	142	Wild Rose (Sweet Briar)
164	Nettles	146	Willow
147	Oak	152	Yardweed
135	Pigweed	140	Yellow Star Thistle

INSECTS

Code No.

301 Ants, Carpenter
302 "Ants"
303 Aphids
304
305

Beetles

306 Asparagus Beetle
307 Blister Beetles
308 Carpet Beetles
309 Colorado Potato Beetle
310 Elm Leaf Beetle
311 Flea Beetles
312 Mint Flea Beetle
313 Powder Post Beetle
314 Sawtooth Grain Beetle
315 Syneta Beetle
316 Tuber Flea Beetle
317 Western Spotted Cucumber Beetle
318
319
320 "Beetles" (unidentified)

Borers

321 Clover Root Borer
322 Peach & Prune Root Borer
323 Peach Twig Borer
324 Raspberry Root Borer
325 Shot Hole Borer
326
327 "Borers"

Bugs

328 Red Bugs
329 Box Elder Bugs
330 Bran Bugs
331 Grass Bugs
332 Lygus Bugs
333 Meadow Spittle Bugs
334 Squash Bugs
335
336
337 "Bugs"

Code No.

Bugs - continued

338 Caterpillars, Tent
339 Chalcid, Clover Seed
340 Cockroaches
341 Curculio, Clover Root
342
343
344
345 Earwigs
346
347 Fleas

Flies

348 Carrot Rust Flies
349 Cherry Fruit Flies
350 Horn Flies
351 House Flies
352 Narcissus Bulb Flies
353
354
355 "Flies"
356 Grasshoppers
357 Grubs, Cattle
358
359 Hoppers, Leaf
360
361 Insects, Scale
362
363
364 Lice, Cattle
365 Lice, Hog
366
367
368
369 "Lice"

Maggots

370 Cabbage Maggot
371 Currant & Gooseberry Maggot
372 Onion Maggot
373 Seed Corn Maggot
374
375 "Maggots"
376 Mange, Hog

INSECTS - continued

Code No.

Maggots - continued

377
378
379 Midge, Clover Flower
380 Midge, Ladino Clover Seed
381
382 "Midge"
383 Millipedes
384 Miner, Spinich Leaf
385
386
387
388

Mites

389 Blackberry Mite
390 Big Bud Mite of Filbert
391 Pear Leaf Blister Mite
392 Spider Mites
393 Walnut Blister Mite
394
395
396 "Mites"
397 Mosquitoes
398
399

Moths

400 Bud Moths
401 Clothes Moths
402 Codling Moth
403 Diamond-Back Moth
404 Flibert Moth
405 Mineola Moth
406
407
408 "Moths"
409 Nitidulids
410
411 Psocids
412 Psylla, Pear
413 Psylla, Boxwood
414
415 "Psylla"

Code No.

416 Silverfish
417 Slugs, Pear
418
419 "Slugs"
420 Spiders
421 Symphyllids
422
423
424 Roller, Filbert Leaf
425 Roller, Oblique Banded Leaf
426
427 "Roller"
428
429 Termites
430 Ticks, Sheep
431
432 "Ticks"
433 Tier, Omniverous Leaf fruit worm (strawberries)
434 Thrip
435 Tortrix, Orange
436
437

Weevils

438 Alfalfa Weevil
439 Clover Leaf Weevil
440 Clover Seed Weevil
441 Granary Weevils
442 Grass Weevils
443 Lesser Clover Leaf Weevil
444 Pea Leaf Weevil
445 Pea Weevil
446 Strawberry Weevil (Root)
447 Vetch Weevil
448
449
450 "Weevils"

INSECTS - continued

Code
No.

Worms

451 Cabbage Worms
452 Corn Ear Worms
453 Cotoneaster Webworm
454 Cutworms
455 Horn Worm
456 Lesser Apple Worm
457 Sod Webworm
458 Spruce Budworm
459 Wireworms
460
461
462 "Worms"

DISEASES

Code No. FUNGI

201 Phytophtora Leaf and Twigg Blight (on holly)
202 Green algae (on holly)
203 Rust
204 Bacterial canker
205 Leaf Spot
206 Leaf and cane Spot
207 Black Spot
208 Dollar Spot
209 Leaf curl
210 Mold
211 Red Thread (Pink Patch)
212 Brown Patch
213 Fruit rot (strawberries)
214 Brown rot (cherries,)
215 Root rot
216 Apple rots
217 Rot
218 Boron Deficiency
219 Zink Deficiency
220 Anthracnose
221 Scab
222 Mildew
223 Fire blight
223 Filbert blight
223 Peach blight

DISEASES - continued

Code No. FUNGI

223 Walnut blight
223 Blight
224 Sycamore Leaf and Twig Blight (anthracnose)

NEMA TODES

275 Root Knot Nematodes
276 Potato eel worms

FERTILIZERS

710 Ammonium Nitrate (Nitraprills)
701 Ammonium Phosphate (Ammophos) 11-48
702 Ammonium Phosphate (Ammophos) 16-20
703 Ammonium Phosphate (Ammophos) 21-53
704 Ammonium Sulphate
718 Anhydrous Ammonia
719 Aqua Ammonia
731 Boron
728 Calcium Nitrate
724 Complete Mixed Fertilizer
723 Concentrated Superphosphate
729 Cyanamid
725 Gypsum
725 Landplaster
730 Lime
721 8-24-0 Liquid, plus Nitrogen
726 Muriate of Rotash
710 Nitraprills
710 Nitrate
720 Nitrogen Solutions (From 20-49 % N)
714 Nu-Green
727 Rotassium Sulphate
732 Sodium Nitrate
704 Sulphate of Ammonia
727 Sulphate of Rotash
722 Superphosphate
723 Treble Superphosphate
720 Uran
714 Urea
750 Other fertilizer

INDIVIDUAL CROPS AND LAND USES

Code No.	CROP LAND
	Cereal grains
01	Barley
02	Corn
03	Oats
04	Rye
05	Wheat
06	Grains grown together as mistures
07	Other grains (buckwheat, emmer, millet, spelts, etc.)
	Hay and Forage crops
08	Alfalfa and alfalfa mixtures
09	Clover and clover mixtures
10	Field peas and mixtures
11	Vetch and vetch mixtures
12	Other legumes
13	Bentgrass
14	Bluegrass
15	Brome
16	Fescue
17	Meadow Foxtail
18	Orchard grass
19	Ryegrass
20	Sudan
21	Tuallatin Oatgrass
22	Wheatgrass
23	Other grasses
24	Root crops, kale, rape, etc., harvested for feed.
25	Pastures (usually cultivated)
26	Summer fallow or idle land
	Specialty field and drug crops
27	Peppermint
28	Sugar beets
29	Flax
30	Dry field beans for food
31	Dry edible field peas
32	Hops
33	Other specialty field and drug crops
	Tree fruits and nuts
34	Apples

35	Apricots
36	Cherries
37	Peaches
38	Pears
39	Prunes and plums
40	Other tree fruits
41	Filberts and hazelnuts
42	Walnuts
43	Other nut trees
	<u>Small fruits</u>
44	Blackberries (tame)
45	Black raspberries
46	Blueberries
47	Boysen and Youngberries
48	Cranberries
49	Gooseberries
50	Grapes
51	Loganberries
52	Red Raspberries
53	Strawberries
54	Other small fruits
	<u>Truck crops</u>
55	Asparagus
56	Beans
57	Beets
58	Cabbage
59	Cantaloupes and Muskmelons
60	Carrots
61	Cauliflower
62	Broccoli
63	Celery
64	Corn, (green)
65	Cucumbers
66	Lettuce
67	Onions
68	Peas
69	Potatoes
70	Rhubarb
71	Spinach
72	Squash and pumpkins
73	Tomatoes
74	Turnips and rutabagas
75	Watermelons
76	Other vegetables

Specialty horticultural crops

77 Nursery crops
78 Flower bulbs, corms, and seed
79 Other specialty horticultural crops

NON-CROP LAND

80 Permanent pasture (non-tillable)
81 Rangeland
82 Timber
83 Other uses (waste, right of ways, fence rows, irrigation ditches, etc.)

CHEMICALS

001 2,4-D (2,4 dichlorophenoxyacetic acid)
002 2,4-DB
003 2,4-DP
004 2,4-DS (crag Herbicide) (SES)
005 2,4,5-T (2,4,5-Trichlorophenoxyacetic acid) (Trioxone)
006 2,4,5-TB
007 2,4,5-TS

020 Alanap (Phthalamic Acid)
021 Aldrin
022 Allethrin
023 Amino Triozole (ATZ)
024 American cyanamid 3911
025 American cyanamid 4124
026 American cyanamid 12008
027 American cyanamid 12009
028 American cyanamid 12013
029 Ammate (Ammonium Sulfamate)
030 Ammonium Sulfate (DNOC) (Elgetol) (Krenite)
031 Aramite
032 Arasan
033 Aromatic Solvent
034 Arsenic compounds
035 Atlacide (Sodium chlorate)
036 Atlas "A" (Sodium Arsenite)
037 Azobenzene

055 Bait

056 Bayer 21/199
057 Bayer 21/200
058 Bayer 28/63
059 Bayer 16259
060 Bayer 17147
061 Bayer L 13/59
062 Benzene Hexachloride (BHC)
063 Bioquin I
064 Boron
065 Borate
066 Borascu
067 Bordeaux
068 Brush Killer
069 Bulan
070 Butoxy Polypropylene Glycol
071 Butoxy Thiocyanodiethyl ether

090 Cadmium Compounds
091 Calcium Arsenate
092 Calcium Cyanamide
093 Calcium Cyanide
094 Calomel (Mecurous Chloride)
095 Captan
096 Carbon bisulfide
097 Ceresan
098 Chloranil (Spergon)
099 Chlorate
100 Chlorax 40 (Chlorax liquid)
101 Chlordane
102 Chlorea
103 Chloro IPC
104 Chlorobenzilate
105 Chloropecrin (Trichoronitromethone)
106 Chlortetracycline
107 Chlorthion
108 Chromate complexes
109 CMU (Karmex W) (Telvar W) (Monuron)
110 Copper
111 Copper Sulfate-Tri basic
112 Corrosive Sublimate (Mecuric Chloride)
113 Crag fungicide 658
114 Crag fruit fungicide 341 C
004 Crag Herbicide (2,4-DS) (SES)
115 Cryolite
116 Cyanamide
117 Cyclethrin

140 Dalapon

203 EPN
204 Ethyl hexanediol

210 Ferbam (Fermate)
211 Furethrin

151 Ginite 923 (Dichlorophenyl Benzene Sulfanate)
215 Glyodin

220 HEPT (Hexaethyl Tetraphosphate)
221 Heptachlor
222 Holcomb Compound 326
223 Hormotox (24-D Amine)

230 Indalone
231 IPC
232 Isobornyl Thiocyan Oacetate
233 Isodrin
234 Isolan

240 Karathane
109 Karmex W (CMU) (Monuron) (Telvar W)
142 Karmex DW (DCMU) (Diuron) (Telvar DW)
030 Krenite (Elgetol) (DNOC) (Ammonium Sulfate)
241 Kolokill

245 Lauseto Neu
246 Lead Arsenate
247 Lime
248 Lindane

255 Magnesium Chlorate
256 Malathion
257 Maleic Hydrazide (MH 40 or 30)
258 Maneb
259 Matlox
260 MCP (MCPA) (Methoxone)
112 Mecuric Chloride (Corrosive Sublimate)
094 Mecurus Chloride (Calomel)
261 Metacide
262 Methaldehyde
260 Methoxones (MCP) (MCPA)
263 Methoxychlor
264 Methyl Bromide

350	Schradan
351	Semesan
352	Sesamin
004	SES
353	Sesamolin
152	Shell DD (Dichloropropane - Dichloropropene) (Dowfume N)
354	Shell OS 1836
355	Shell OS 2046
356	Silvex
159	Sinox PE (Amine DNOSBP) (Dinitro Amine) (Premerge)
160	Sinox W (NH4DNOSBP) (Dow Selective) (Dinitro Selective)
357	Streptomycin
358	Sodium Arsenate
036	Sodium Arsenite (Atlas "A")
035	Sodium Cyanamide
360	Sodium Ethyl Xanthate
098	Spergon (Chloranil)
361	Strobane
362	Strychnine
363	Sulfur
364	Sulfotepp
365	Sulfoxide
366	Sulpheone
146	Systox (Demeton)
380	Tarter Emetic
381	TCA
143	TDE (DDD)
109	Telvar W (Karmex W) (CMU) (Monuron)
142	Telvar DW (Karmex DW) (DCMU) (Diuron)
382	TEPP
304	Terrador (Pentachloronitrobenzene)
383	Thiocyanoethyl laurate
384	Thiram
385	Thylate
386	Toxaphene
111	Tri-basic Copper Sulfate
105	Tri Choronitromethane (Chloropecrin)
400	Ureabor
405	Vapam
406	Virus

410 Yellow Cuprous Oxide
411 Yellow Cuprocide

415 Zerlate
416 Zinc
417 Zineb
418 Ziram