EM 8568
September 1994
$8.00

Pesticide Use Survey

Oregon Pesticide Use Estimates for Seed and Specialty Crops, 1992

OREGON STATE UNIVERSITY EXTENSION SERVICE

Ordering information

If you would like additional copies of EM 8568, *Oregon Pesticide Use Estimates for Seed and Specialty Crops, 1992,* send $8.00 per copy to:

Publications Orders
Agricultural Communications
Oregon State University
Administrative Services A-422
Corvallis, OR 97331-2119

Pesticide Use Survey

Oregon Pesticide Use Estimates for Seed and Specialty Crops, 1992

By
John Rinehold, Extension pest impact assessment coordinator,
Jeffrey J. Jenkins, Extension agricultural chemist,
Oregon State University

EM 8568
September 1994

This report, *Oregon Pesticide Use Estimates for Seed and Specialty Crops, 1992,* is the third of five statewide pesticide use surveys covering (1) small fruits, (2) tree fruits, (3) seed and specialty crops, (4) vegetable crops, and (5) small grains, forage crops, and livestock. Oregon Pesticide Impact Assessment Program's objective is to complete one survey per year for 5 years, resulting in an overall estimate of the magnitude of agricultural pesticide use in Oregon.

Contents

Introduction

The Oregon Pesticide Impact Assessment Program (OPIAP) prepares reports on the use and importance of pesticides in Oregon. These reports summarize research data and pest biology, estimate chemical use, and postulate the economic impact on growers following removal of a pesticide from crop registration. OPIAP also provides data to the United States Department of Agriculture, Environmental Protection Agency, Oregon Department of Agriculture, and other agencies that make or influence regulatory decisions.

The report, *Oregon Pesticide Use Estimates for Seed and Specialty Crops,* is the third in a series of five statewide pesticide use surveys covering (1) small fruits, (2) tree fruits, (3) seed and specialty crops, (4) vegetable crops, and (5) small grains, forage crops, and livestock. OPIAP's objective is to complete one survey each year over 5 years, resulting in an overall estimate of the magnitude of agricultural pesticide use in Oregon.

Information Gathering

Assimilating pesticide use information is a complex process. In most cases information on pesticide use is gathered through well-designed surveys of pesticide dealers, users, and those who advise users. No matter how well the surveys are designed, however, cooperation from growers, grower groups, and research and extension personnel is essential to a comprehensive survey. Knowledge of crop and pest biology, agronomic practices, and pesticide use practices is fundamental to proper interpretation of survey data. The use of computers and relational database technology provide a platform for standardized data organization. In addition, this technology allows for complex queries of the database information and facilitates the integration of database information with text and graphics in report preparation.

The diversity of Oregon's agriculture makes the process more complex. Over 160 different crops are grown in Oregon. Of these, 84 grossed over a million dollars in annual sales in 1992. Oregon's cropland is distributed among a number of regions with dissimilar climate and topography. For example, central, south central, and eastern Oregon croplands are on high desert plateaus. These regions are generally dry except in the mountains. Western Oregon valleys and coastal croplands are dry during most of the growing season, but wet during the rest of the year.

Procedure

In 1992, the OPIAP conducted a survey on pesticide use on seed crops and specialty crops in Oregon. For the years 1977, 1978, and 1979, OPIAP took a census of the distribution of 2,4-D and MCPA by the pesticide dealers and use by applicators across the state. The 2,4-D survey was limited to forest and agriculture uses and was based on use records and dealer opinions. The report probably overestimated actual use due to two undetected factors: duplicate reporting by dealers and applicators and products sold in Oregon and used outside the state.

Early Use Surveys

The 1981 statewide pesticide use survey was conducted for commonly used pesticides. Some crops were grouped together. For example, wheat, oats, barley, and rye were grouped as small grains. This survey did not include pesticide control operator (PCO) and nursery uses, but it did attempt to look at some home and garden use. Information was gathered by polling pesticide dealers, applicators, fieldmen, agricultural consultants, county agents, and other experts. Limited resources precluded surveying many minor crops such as carrot seed and sugar beet seed. These data gaps made extrapolation to statewide use difficult. In addition, some pesticides, such as lime sulfur, were completely missed, resulting in as much as a quarter million lb active ingredient unreported. The estimated total pesticide usage in 1981 was 13,800,000 lb active ingredient.

The 1987 pesticide use survey was the third major attempt to collect statewide pesticide information and our second statewide pesticide use survey. This survey employed county agents and pesticide dealers extensively, but also fieldmen, agricultural consultants, experiment station specialists, PCOs, and others. It was structured to collect information by county, and procedures were adopted to limit spurious data. There was difficulty in estimating treated acreage for some crops. In 1987, 3035 acres of grapes were harvested, but an additional 1440 nonbearing acres required pesticides. Other nonbearing crops pose a problem in determining pesticide use. A total of 199 active ingredients were tabulated with a statewide pesticide use totaling 16,050,000 lb.

Five-Year Series

The 1990 pesticide use survey was the first in a 5-year series surveying pesticide use in Oregon and focused on small fruit production. This survey targeted growers only, and it relied on their use records or estimates. We chose to survey growers rather than experts in the field, such as industry fieldmen, agricultural consultants, and county agents. We normally prefer to interview the experts, but the small fruit industry does not easily lend itself to this method. Many growers market their fruit independently of processors. The few processors that do have fieldmen do not work extensively with some of the small fruits, including grapes, blueberries, currants, and gooseberries. The small fruit crops surveyed included these:

- blackberries
- raspberries
- blueberries
- strawberries
- cranberries
- gooseberries
- currants
- grapes

In addition to data collected in past surveys, more detailed information was acquired on pests treated, varieties treated, and types of application equipment and protective clothing used.

The 1991 tree fruit and nut pesticide use survey was conducted with the assistance of agricultural consultants, packing house supervisors, pesticide dealers, and county agents. There are many tree fruit experts throughout Oregon, and we felt that by surveying those people, we could get a better picture of the pesticide use than we could from surveying growers.

The 1992 survey was conducted with assistance from private agricultural consultants and advisors, agronomists, pesticide dealers, and university specialists. Historical use data were collected from industry journals and newsletters, previous pesticide surveys, research and extension papers, and personal interviews. Crop acre estimates were obtained from the Extension Economic Information Office (EEIO) at Oregon State University, NASS, the USDA Crop Reporting Board, and the U.S. Census of 1880, 1890, 1900, and 1910. These agencies publish production data on most Oregon agricultural commodities. Data include planted and harvested acres, yield, production, and dollar sales.

Data Collection

Pesticide use data that are collected from experts in the field are reliable. Those not acquainted with pesticide use often have the misconception that valid numbers are derived only through grower surveys. We maintain that grower surveys are opinion polls, and, as such, reflect only what the grower perceives as fact. Most growers do not keep pesticide application records, most do not apply pesticides to all their crops, and most rely on a consultant's advice when treating a crop. Oregon's best growers depend upon agricultural advisors. Private agricultural advisors are well educated. They normally hold a master's degree or a Ph.D. in agronomy or a related field. They and their staffs monitor crops regularly and thoroughly understand the principles of integrated pest management. Additionally, most of the crops in Oregon are grown within a small area. Hops, for example, are raised by about 40 growers who live within a few miles of each other. Sugar beets are grown in an even smaller area in Malheur County, and carrot seed is grown entirely in Jefferson County. Agricultural advisors become familiar with crops in such small areas and have good judgments on the magnitude of pest problems and the use of chemical and nonchemical treatments to manage these pests.

The peppermint pesticide use data were collected from selected growers through a questionnaire delivered by mail. The Oregon State University statistics department developed the survey with the assistance of the Oregon Essential Oils League.

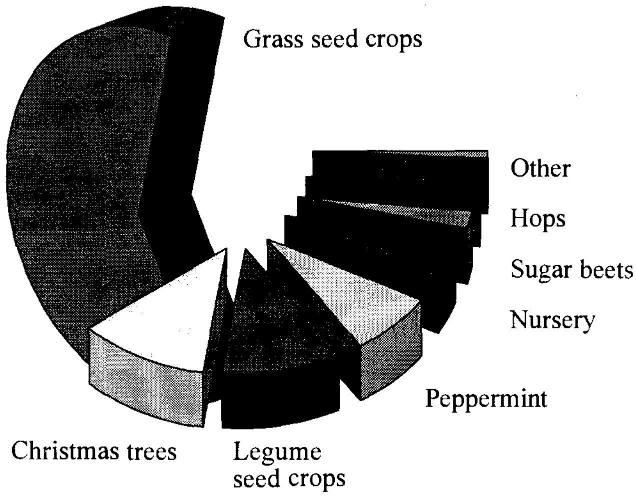
The Christmas tree plantation acreage in production in Oregon is not known, but it is estimated between 60,000 and 65,000 acres. About 15 percent of the growers have three-quarters of the acreage. As a result of these uncertainties, this report cites the amount of pesticide used based upon the pesticide practices of the larger growers. Smaller growers are not included in the estimates on the assumption that if they use pesticides, they use them in small amounts. The OPIAP has been cooperating with the Pacific Northwest Christmas Tree Growers Association to develop an annual pesticide use survey of their members that covers aspects of pesticide use critical to reregistration. Aside from amounts used and pests treated, it will detail economic losses due to pest impacts on yield and quality. This in-house survey was adapted from the Michigan Christmas Tree Pesticide Use Survey developed at Michigan State University.

The many varieties of plants grown and the different agronomic practices make it difficult to determine the individual acreage of vegetable and flower seed crops and nursery crops in Oregon. The OPIAP interviewed eight vegetable and flower seed company agricultural advisors and used that information to estimate current pesticide use and associated pest problems.

Because there are over 500 ornamental plant nurseries in the state, we chose to interview ten of the largest plant nurseries and the 3 main pesticide dealers who sell to the nursery industry. With the many thousands of species of nursery plants grown and the many more varieties of these species, pesticide use reporting had to be done on some basis other than by crop. We divided nursery crops into five major categories based on agronomic practices rather than plant species: (1) container nurseries, (2) field trees and shrubs, (3) color and bedding plants, (4) cut flowers, and (5) ornamental bulbs.

Summary

Figure 1. Relative Acreage Devoted to Seed and Specialty Crops, 1992.



Production

Oregon seed crops and specialty crops have grown in importance over the past century. Some, such as flax, have disappeared from what was previously a large production. Others, like nursery crops, have become large and important businesses, employing tens of thousands of people in the state. It is helpful to compare pesticide use data with production data. In 1992, nursery crops ranked second in dollar sales of all Oregon agricultural commodities (see

Figure 2. Relative Amounts of Pesticides Used for Oregon Seed and Specialty Crops, 1992.

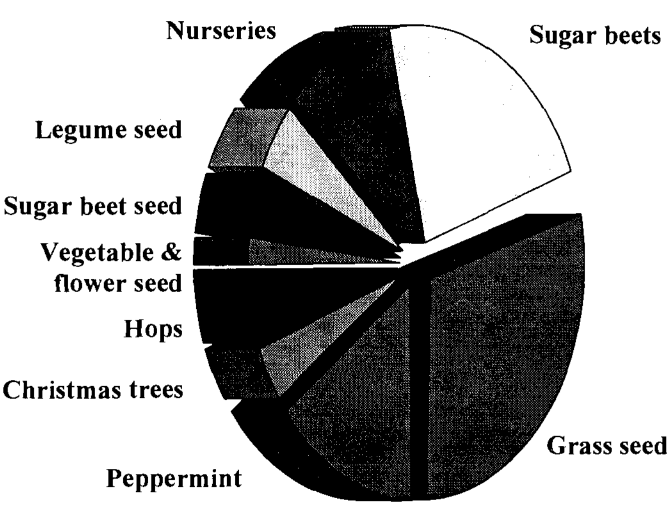


Table 1). The relative acreage devoted to seed and specialty crops is shown in Figure 1. Table 1 contains summary data from 1992. The "Rank" column orders seed and specialty crops among the other Oregon agricultural commodities according to dollar sales.

Table 1. Major Oregon Seed and Specialty Crops Ranked by Gross Dollar Sales, 1992.

Commodity	Rank	Dollar Value	Acres
Nursery crops	#2	$274,200,000	26,700
Christmas trees	#7	70,753,000	46,160
Perennial ryegrass	#13	54,313,000	113,000
Peppermint oil	#13	46,667,000	45,870
Annual ryegrass	#16	37,712,000	117,000
Tall fescue	#18	33,155,000	85,290
Hops	#23	21,338,000	7,900
Sugar beets	#28	15,968,000	19,000
Vegetable & flower	#31	14,862,000	5,800
Bentgrass	#34	12,062,000	16,630
Kentucky bluegrass	#35	11,013,000	14,650
Bulbs	#36	10,500,000	1,000
Orchardgrass	#42	8,865,000	18,700
Red clover	#44	7,088,000	18,750
Chewings fescue	#45	6,849,000	16,600
Sugar beet seed	#46	6,197,000	5,460
Garlic	#47	5,959,000	——
Alfalfa seed	#50	5,375,000	7,640
Crimson clover	#59	4,104,000	10,830
Red fescue	#63	3,305,000	9,360
Spearmint oil	#66	2,835,000	2,000
Arrowleaf clover	#68	2,245,000	——
Hard fescue	#73	1,753,000	——

1992 Oregon County and State Agricultural Estimates, Special Report 790 / Revised January 1993, Oregon State University Extension Service.

Pesticide Use

A total of 116 active ingredients were tabulated in the 1992 seed and specialty crop pesticide use survey. Pesticide use by class is tabulated in Table 2. Herbicides are the largest single contributor to the estimates with about 47 percent of use, followed by fungicide and insecticide use. The relative amounts of all pesticides used on each crop are seen in Figure 2.

Some of the 10 most frequently used seed and specialty crops pesticides have changed positions in the rankings since the 1981 survey. Contributing to the increase in the total amount of pesticides used since 1981 were broader surveys and the increase in severity of certain pests. The 1981 survey did not include nurseries, Christmas trees, sugar beets, vegetable seed, and flower seed. Pests, such

Table 2. Pesticide Use on Oregon Seed and Specialty Crops, 1992.

Pesticide Class	Pounds a.i.*	Percentage
Herbicides	1,390,000	47%
Fungicides	810,000	28%
Insecticides	580,000	20%
Acaricides	110,000	4%
Fumigants	44,000	1%
Desiccants	3,600	<1%
Mollusk poisons	3,600	<1%
All growth regulators	3,300	<1%
Bactericides	70	<1%
Vertebrate poisons	negligible	<1%
Total	2,950,000	100%

*Active ingredient estimates are rounded.

as spider mites and powdery mildew, were in greater abundance in 1992 than in 1981 and required greater control. Table 3 compares the 1981 and 1987 surveys with the current survey. Some of the pesticides in the 1981 and 1987 surveys have dropped from the top ten list, and they are listed below the dotted line. Table 4 contains a complete listing of pesticides used on seed and specialty crops.

Family farms and corporate growers have always been interested in the safe use of pesticides and know the importance of pesticides in the production of high quality crops. Growers use a wide variety of cultural agronomic practices to replace or supplement the pesticide use on crops. Mint, hops, grass seed, and alfalfa seed crops are examples of crops successfully grown with integrated pest management (IPM) practices. IPM techniques are not as well developed for use on other crops noted in this report. Although pesticide use on these crops appears to have increased over the past decade, this actually may not be the case. The 1981 survey was incomplete and did not account for treatments on sugar beets for sugar, nursery crops, Christmas tree plantation, and vegetable and flower

Table 3. Comparison of the 1981, 1987, and 1992 Top Ten Pesticides Used on Seed and Specialty Crops.

Common Name	1992 Survey Rank	1992 Survey Pounds	1987 Survey Rank	1987 Survey Pounds	1981 Survey Rank	1981 Survey Pounds
Sulfur	#1	620,000	#10	47,000	#8	47,000
Diuron	#2	420,000	#2	250,000	#12	41,000
Terbufos	#3	210,000	#43	4,900	—	—
Glyphosate	#4	100,000	#16	34,000	#18	20,000
Propargite	#5	100,000	#15	34,000	#19	18,000
2,4-D	#6	99,000	#4	110,000	#5	83,000
Terbacil	#7	80,000	#17	32,000	#11	44,000
Chlorpyrifos	#8	79,000	#8	54,000	#28	12,000
Cycloate	#9	76,000	#11	45,000	#21	15,000
Bentazon	#10	72,000	#61	1,500	#7	51,000

Chlorothalonil	#15	52,000	#6	83,000	#34	6,400
Mancozeb	#38	10,000	—	—	#1	110,000
Nickel sulfate	—	—	#52	3,500	#2	100,000
Atrazine	#20	42,000	#1	260,000	#3	95,000
Bordeaux	#87	300	#25	11,000	#4	88,000
1,3-Dichloropropene	#31	20,000	#18	22,000	#6	63,000
Fonofos	#13	69,000	#12	45,000	#9	47,000
Dinoseb	—	—	#59	2,100	#10	45,000
Asulam	—	—	—	—	#13	41,000
Simazine	#39	10,000	#5	95,000	#49	1,300
Dicamba	#22	27,000	#9	52,000	#33	7,000
Ethofumesate	#18	50,000	#7	75,000	#15	24,000
Maneb	—	—	#3	250,000	—	—

seed crops. There was major increase in the 1994 pesticide use in sulfur on sugar beets of about 400,000 lb.

Grass Seed Crops

These are times of change for the grass seed industry. A large portion of the southern Willamette Valley is a low lying plain with moderate to heavy clay soils. These are often wetlands in the winter and are unsuitable, in general, for any agronomic crop other than grass for seed. This area has the greatest concentration of grass seed grown for seed in the United States. Field burning was developed in the 1950's and became the standard cultural practice for destroying seed that produces off types, seedlings of the same variety that are genetically different. It was also a successful method of controlling diseases, as well as a method to return fertilizer to the soil. However, for over 30 years, citizen complaints about field burning have increased. The large amount of particulate matter causes breathing discomfort and creates a hazard to traffic. Each year, the Oregon Legislature has systematically reduced the number of acres that may be burned and a complete ban on burning may be implemented in the near future. Thus, new methods of crop residue management need to be developed. Without field burning, herbicides that destroy specific grass seeds are needed more than ever. A full registration of Goal, which controls volunteer grass in unburned stands, is being pursued. The significant decrease in the amount of atrazine applied to grass seed crops, over 200,000 lb, resulted in the increased use of diuron, of about the same amount.

Legume Seed Crops

Pollinating insects are essential to legume seed production, but at the same time Lygus bugs in alfalfa seed crops reduce yields by destroying the seed. Growers have been able to stay one step ahead of *Lygus* by applying Capture, a synthetic pyrethroid, which has become a mainstay of the alfalfa seed industry. Capture has replaced Metasystox-R as the preferred treatment for *Lygus.* Some growers hope that Karate, a similar insecticide, will be registered, and that its use will help prevent insect resistance to Capture.

The clover root curculio is a limiting factor to red clover seed production in Oregon. Curculio was controlled with DDT, aldrin, and chlordane in the past, but today no effective materials are registered.

Sugar Beet Seed Crop

The sugar beet seed crop is peculiar only to Oregon. Herbicide practices, which have not changed significantly in the past dozen years, appear to be changing. Repeated (every 5 to 7 days) banded applications of low rates of Betamix have been found to control late germinating summer annual weeds, as well as winter annuals. This would change the conventional method of using one application at a high rate. Herbicide 273, used in the winter, is now used at a lower rate when applied with liquid nitrogen. The cost is the same, but the weed control is better with an added bonus of fertilizer.

Vegetable and Flower Seed Crops

Many vegetable and flower seed crops are grown in Oregon, but few pesticides are registered for use on flower seed crops. As a result, it is important to plant seed in a field free of weed seed in order to avoid a great deal of cultivation and hand hoeing later. Treflan is the most widely used herbicide in the production of vegetable and flower seeds.

Hybrid varieties, in comparison with open pollinated varieties, produce valuable seed. Even a small amount of insect or disease damage lowers grower profits.

Hops

No major crop is as dependent upon one industry as hops, which are sold to breweries. The breweries demand hops with an unblemished appearance. The appearance of the hops is not necessarily related to quality, but this demand forces the growers to depend upon pesticides. Since 1929, when downy mildew first appeared in hops, growers have attempted to control this disease and today largely depend upon Ridomil and Aliette (Section 18) to maintain control. Mites can also be a severe problem any year. Omite and Abamectin (Section 18) are favored for treatment. The hop aphid is always a serious pest. Diazinon, Brigade (Section 18), and Lorsban (Section 18) are also frequently used to maintain high quality, blemish-free hops. However, on May 7, 1993, the Aliette and Brigade emergency registrations were revoked. IPM techniques must also be used to control aphids and mites because a chemical that controls one can cause the other to flare up. And, unlike other crops, extensive cultivation practices result in a low herbicide usage on hops.

Peppermint

Mint is plagued with many debilitating diseases and insects that, for the most part, were carried into the state on contaminated nursery stock. The two most serious diseases are verticillium wilt and mint rust. Both are suppressed by sanitation practices such as propane flaming and the use of disease free mint root stock. Several cutworms, root weevils, spider mites, nematodes, mint flea beetles, and mint root borers are also very injurious insects. Lorsban and Orthene are used extensively for the cutworm, Orthene for the strawberry root weevil, Lannate for the mint flea beetle, and Comite for twospotted spider mites. Weeds impart undesirable flavors to the mint oils when they are distilled along with the mint, so they must be controlled. Sinbar has been the mainstay for weed control because it controls a wide variety of weeds and mint is tolerant to it. Sinbar, Karmex, and Goal are applied preemergence, while Stinger and Buctril are applied postemergence.

Table 4. Pesticide Use on Oregon Seed and Specialty Crops. Ranking by Pounds Used in Descending Order.

Rank	Common Name	lbs Used	Rank	Common Name	lbs Used	Rank	Common Name	lbs Used
1	Sulfur	620,000	41	Endothall	8,700	81	Alachlor	500
2	Diuron	420,000	42	Oxamyl	8,700	82	Disulfoton	500
3	Terbufos	210,000	43	Bifenthrin	8,400	83	Fosetyl-Al	450
4	Glyphosate	100,000	44	Dicofol	7,500	84	Methidathion	380
5	Propargite	100,000	45	Pronamide	6,900	85	Azinphos-methyl	360
6	2,4-D	99,000	46	Pyrazon	6,800	86	Bordeaux	300
7	Terbacil	80,000	47	Sethoxydim	6,700	87	Dodine	300
8	Chlorpyrifos	79,000	48	Carbofuran	6,700	88	Fenamiphos	280
9	Cycloate	76,000	49	Endosulfan	6,600	89	Etridiazole	270
10	Bentazon	72,000	50	Methomyl	4,800	90	Abamectin	240
11	Acephate	72,000	51	Metolachlor	4,800	91	DCPA	230
12	Copper	70,000	52	Aldicarb	4,300	92	Dienochlor	230
13	Fonofos	69,000	53	Dichlobenil	4,200	93	Ethalfluralin	220
14	EPTC	52,000	54	Methyl bromide	4,000	94	Fluazifop-butyl	220
15	Chlorothalonil	52,000	55	*Bacillus thuringiensis*	3,600	95	Cypermethrin	200
16	Propioconazole	52,000	56	Malathion	3,600	96	Thiabendazole	150
17	Ethofumesate	50,000	57	Metaldehyde	3,600	97	Metam-Sodium	150
18	Oxyfluorfen	45,000	58	Diquat	3,600	98	Cyanazine	140
19	MCPA	43,000	59	Dimethoate	3,500	99	Triflumizole	120
20	Atrazine	42,000	60	Bendiocarb	3,300	100	Methyl parathion	110
21	Paraquat	42,000	61	Linuron	2,600	101	Oxycarboxin	110
22	Dicamba	27,000	62	Methoxychlor	2,400	102	Permethrin	110
23	Bromoxynil	26,000	63	Benomyl	2,300	103	Thiram	110
24	Pendimethalin	26,000	64	Benefin	2,200	104	Dodemorph acetate	100
25	Diazinon	23,000	65	Norflurazon	2,200	105	Phosmet	100
26	Triclorfon	23,000	66	Thiophanate-methyl	2,000	106	Pyrethrins	100
27	Clopyralid	23,000	67	Iprodione	1,900	107	Fluvalinate	90
28	Napropamide	22,000	68	Desmedipham	1,700	108	Streptomycin	70
29	Naled	20,000	69	Mevinphos	1,600	109	Esfenvalerate	25
30	Oil	20,000	70	Isoxaben	1,400	110	Vinclozolin	25
31	1,3-Dichloropropene	20,000	71	Bensulide	1,200	111	Fenvalerate	20
32	Metribuzin	16,000	72	PCNB	1,000	112	Lambda-cyhalothrin	12
33	Oxydemeton-methyl	15,000	73	Oxythioquinox	910	113	Imazethapyr	10
34	Oryzalin	15,000	74	Chlorpropham	900	114	Temephos	10
35	Carbaryl	14,000	75	Lime sulfur	900	115	Gibberellic acid	5
36	Hexazinone	14,000	76	Metalaxyl	900	116	BioVector	—
37	Trifluralin	13,000	77	2,4-DB	670			
38	Mancozeb	10,000	78	Triadimefon	620			
39	Simazine	10,000	79	Captan	600			
40	Oxadiazon	9,900	80	Fenbutatin-Oxide	510			

Sugar Beets

Sugar beets have a large number of debilitating diseases and insect pests, as does peppermint. The worst disease throughout the West was curly top, and only through host resistance to the virus, which is carried by the beet leafhopper, could this disease be brought under control. In addition, there are other historic pests:

wireworms
white grubs
leafminers
leafhoppers
cercospora leaf spot

Three more pests were introduced into the Magic Valley from different producing areas: powdery mildew in 1974, root maggots in 1982, and crown borers somewhat later.

Finally, growers have noticed an increase of wireworms in the past 5 years as DDT residues have declined.

Many weeds, such as pigweed and Russian thistle, are troublesome, but kochia, the worst, exudes a toxin that inhibits sugar beet growth. Betamix and Nortron are used increasingly for weed control.

Christmas Tree Plantations

Most Christmas tree plantations grow Douglas-fir. Because it is indigenous to the Pacific Northwest, it has very few serious pests. The biggest cause of tree death is actually drought. Swiss needle cast is a serious disease on Douglas-fir, but it is controlled with Bravo.

In the early 1980's, weed control was recognized as being essential to the production of high quality trees. In the mid-1980's, a change in label interpretation resulted in a change in the use of products. Since that time, Christmas trees have had to be specifically mentioned on the label before the product could be applied to Christmas tree plantations. The listing of ornamental plant or fir trees does not permit the product to be used on Christmas trees. Atrazine, which was previously the most commonly used herbicide on Christmas tree plantations, has been supplanted by Goal and Velpar.

Nursery Crops

Nurseries grow a diverse group of plants, and every general statement covering a nursery crop will have an exception. Pesticide registrations for ornamental plants need to be general in order to cover the enormous number of plant species. Because these plants are grown in close proximity to one another, it is costly and time consuming to apply the right pesticide on the right pest at the right time. Nonetheless, perfect plant quality is necessary to sell the ornamentals. Pesticides are applied only when absolutely necessary and sometimes not at all. This means that growers commonly destroy crops that are weed-, insect-, or disease-infested. In one such instance, a quarter acre of irises choked out by weeds was tilled under at a loss of over $36,000.

Grass Seed Crops

Production

Sweden is credited as the first country to produce quality grass seed. The Germans were the first to merchandise grass seed (tall fescue and bentgrass) in the 18th century.

In Oregon, seed crops date back to the early period of agricultural settlement; however, the development of the commercial seed industry (as it now exists) had its start in the 1900's. In this early period of seed production, marketing or exchange was based on a farm-to-farm barter basis. Later, feed seed and crop seed were handled independently.

In the early 1920's, agricultural leaders gave serious thought to the production of seed crops. They recognized the need for more cash crops, more diversity of crop production, and the national need for seeds for a wider range of field crops for forage turf, soil protection, and soil improvement. In addition, the country needed larger domestic supplies of seed since adequate foreign supplies were not always available.

Oregon is hospitable to seed growers. Its fertile land and favorable climate make it possible for farmers to grow a wide range of seed crops. Most field crops (legumes, grasses, and others) adapted to northern or semi-northern latitudes can be grown as seed crops in Oregon.

Oregon growers began selling clean seed, rather than by-product grass or legume seeds harvested from a hay field or pasture. The resulting large quantities of quality seed attracted the attention of wholesalers.

Many of the current commercial grass seed varieties were introduced into the state in about 1920, and, by the 1930's, Oregon was noted as an important seed producing state. Oregon seed was used primarily for soil conservation and for the production of forage and turf.

Farm and commercial plants began processing seed as production expanded; marketing and storage expanded as well. The cleaned seed from these plants was either marketed directly by the owners or through large commercial plants. Contract growing of seed developed by mid-century and continued to expand. Figures 3, 4, and 5 note

Figure 3. Annual Bearing Acres of Oregon Grass Seed Crops, 1880-1992.*

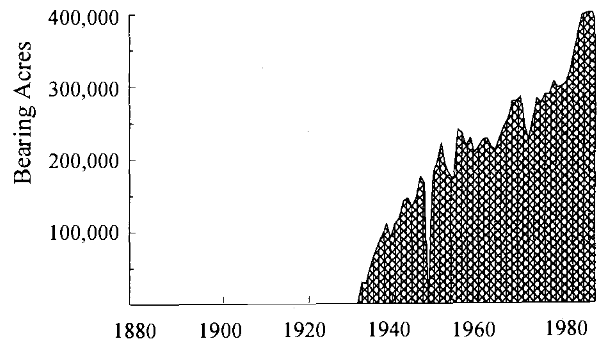


Figure 4. Annual Production of Oregon Grass Seed, 1880-1992.*

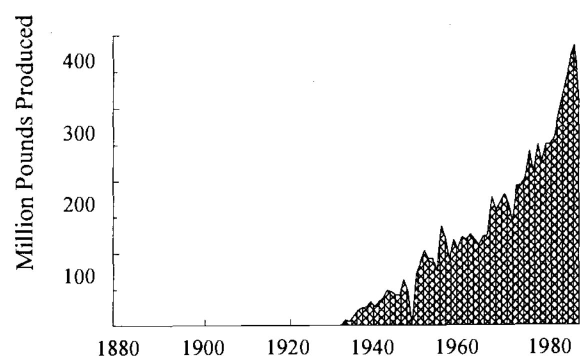
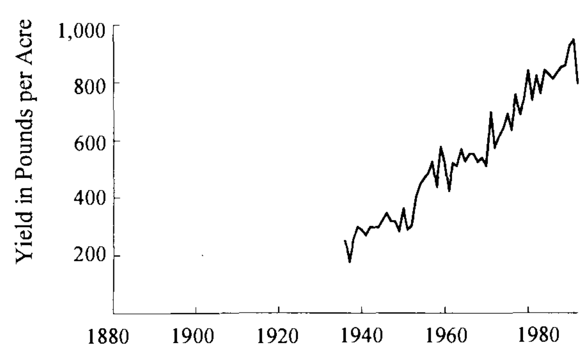


Figure 5. Annual Average Yield of Oregon Grass Seed Crops, 1880-1992.*



*Information compiled from Seed Crops, USDA Bureau of Agricultural Economics, 1939-51; Seed Crops, USDA Agricultural Marketing Service, CRB, 1952-60; Seed Crops, USDA SRS, Crop Reporting Board, 1960-76; Seed Crops, USDA ESCS, Crop Reporting Board, 1977-80; Extension Economic Information Office, OSU, 1981-92.

the increases in acreage, production, and yield of grass seed crops from 1880 to 1992.

Harvesting methods and equipment have also improved. Harvest can be completed in a shorter time, more of the seed is saved, labor is reduced, and often the quality of the seed is improved. Agricultural consultants scout fields regularly to ensure proper management for highest yields and quality.

Processing and storage equipment likewise are better. Bulk handling of various kinds of seeds has become common practice. Influential agricultural organizations such as farmer groups, seed commissions, and public agricultural interests such as USDA, OSDA, and OSC played an important part in furthering seed production in the state.

Breeding programs have provided seed growers the opportunity to produce improved field crop seed that is of high quality, but cheaper than seed available in many parts of the world. Because it is costly to develop a new variety of seed, some protection was needed to make sure that the consumer would receive the plant breeder's original design. In 1919, a group of agronomists established some basic and preliminary ground rules for seed certification. While these rules have become more complex and sophisticated, the purpose of seed certification was to provide a means whereby a given amount of seed stock, when made available by the plant breeder, could be multiplied into large volumes and still retain its original genetic characteristics. For about 50 years, a United States and Canadian organization, known as the International Crop Improvement Association, and, later, the Association of Official Seed Certifying Agencies, helped in the interstate and inter-county movement of seed. Subsequently, states passed legislation to establish a certification agency as a legal entity. In Oregon, this responsibility was assigned to Oregon State University by state statute.

Seed testing laboratories are essential to the maintenance of seed quality. They monitor such things as the presence of noxious weeds or debris and the percentage of germination in seeds. There are several state, company and private seed testing organizations in Oregon. Seed certification programs also help improve seed quality by verifying authenticity of seed varieties. Such programs, in conjunction with seed testing laboratories, result in improved domestic and foreign seed distribution.

Annual ryegrass, previously known as common ryegrass, has had production fluctuations from year to year. Since 1936, production has ranged from a low of 7 million lb in 1937 to a high of 231 million lb in 1977. Yields have ranged from 257 lb per acre in 1937 to 1800 lb per acre in 1991. Annual ryegrass is grown primarily in the southern Willamette Valley, which is suitable for grass and pasture but little else.

Perennial ryegrass was introduced into Oregon in about 1936. Annual and perennial ryegrass are the two most valuable grass seed crops in Oregon. Most of the seed in the United States comes from Oregon.

Tall fescue, grown throughout the Willamette Valley, was introduced into Oregon in 1916, but wasn't harvested commercially until 1938. Chewings fescue was first grown commercially in Oregon in 1930. Red fescue was introduced after Chewings fescue, but only 100 acres were in production in 1940.

Bentgrasses were introduced into Coos County, Oregon in 1923. Oregon remained the only commercial producer of bentgrass seed until 1949 when Washington began growing the seed.

Historical Pesticide Use in Grass Seed Crops

Pre War

When grasses became important seed crops in Oregon, pesticides were not commonly used. At the turn of the century, growers began to occasionally adopt chemical control measures for weed and insect problems. Some of the pesticides important to grass seed crops are shown in Figure 7. This list is not inclusive, but it shows which pesticides were used predominately and were not simply available. Weeds were a serious problem, and weed control was one of the most important considerations in production. The only two herbicides of value were sodium chlorate and carbon bisulfide. Both were used in spot treatments of noxious weeds, but they were quite flammable. Carbon bisulfide was injected into the ground at high rates (from 400 to 600 lb per acre), and sodium chlorate sterilized the soil for several years after being applied at the normal rate of 150 to 300 lb per acre. Growers attempted general weed control through tillage practices, smother crops, crop rotation, field burning, or fallow. Following the implementation of the Agricultural Adjustment Act (AAA) in the early 1930's, control and eradication of noxious weeds was administered by the government, but effective weed control came only with the advent of new effective herbicides. The Oregon Seed Law regulated the amount of certain noxious weed seed allowable in grass seed crops: field bindweed, Canada thistle, and tansy ragwort in western Oregon and Russian knapweed, whitetop, St. Johnswort, and leafy spurge in eastern Oregon.

Field mice, if troublesome, were often controlled with strychnine poisoned grain. While trapping field mice was not effective, trapping gophers was. In the spring, when gophers were bearing young, sometimes growers would asphyxiate entire families by directing exhaust fumes into gopher runs.

Post War

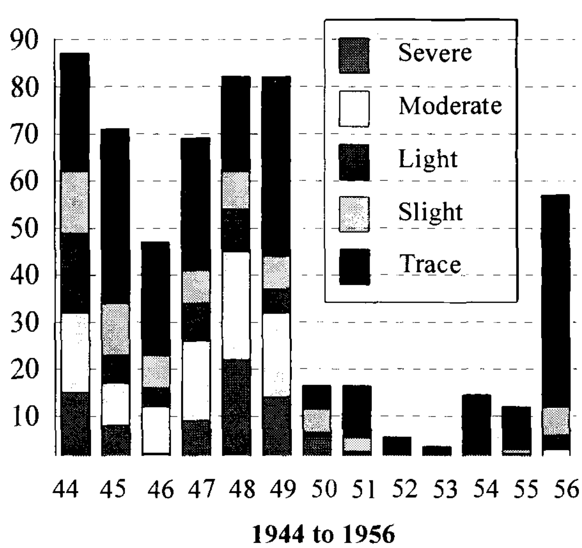
The seed industry was on hold during World War II. By 1945, ammonium thiocyanate, Shell DD and 2,4-D were being used experimentally and appeared to hold great promise for the seed industry. DD was a fumigant applied at 400 to 600 lb per acre and was often used in spot treatment to control quackgrass. At that time, the only way to control quackgrass was to deep plow, harrow, and follow by planting an oats-vetch cover crop. This process was repeated the following year.

Sodium fluosilicate bait was the standard control for grasshoppers, and the USDA provided bait without charge. In the late 1940's, chlordane and toxaphene were used, and by the mid 1950's, aldrin and heptachlor were applied for grasshopper control.

Cutworms, like grasshoppers, were common problems in central and eastern Oregon. Insecticides were only partially effective on the redbacked cutworm, a serious problem on central Oregon grass seed crops.

Blind seed disease on perennial ryegrass was one of the most critical problems affecting forage seed crop production by the beginning of World War II. The first low germination samples were noticed in the 1941 season, and by 1944, the disease was found in 85 percent of the certified seed samples. This disease, caused by a fungus that kills the seed, was controlled by plowing under badly infested-fields and keeping them out of production for two years.

Figure 6. Percentage of Blind Seed Disease in Oregon Perennial Ryegrass Fields.



Proceedings of the Sixteenth Annual Meeting of the Oregon Seed Growers League, December 1956.

Specialists also recommended that only 2-year-old seed be planted (the fungus would have died by then), and that care should be taken to eliminate sources of reinfestation such as contamination by fence row grass seeds and seed shattering during harvest. Blind seed disease continued to reduce seed quality, and in 1948, about one-third of the fields needed to be plowed under. From 1949 on, Oregon crops had negligible damage as a result of four basic cultural practices: (1) planting 2-year-old seed, (2) collecting all seed from the fields, (3) plowing infested fields, and (4) burning fields each year. Field burning was the most important practice to decontaminate infected fields. Thus, in all of the United States, only the Oregon perennial ryegrass seed growers had gained control of blindseed disease. In 1956, after 6 consecutive years of excellent disease control, there was a significant increase in the prevalence of blind seed disease (Figure 6). About 14 percent of the 1956 crop was plowed under because growers had neglected control practices.

Ergot, an old problem on bentgrass and perennial ryegrass, had no chemical controls. Normally, growers tried to control ergot by eliminating the regrowth heads via clipping and burning the field after harvest. The ergot sclerotia was long-lived, but burning helped reduce the damage by destroying these fungal bodies. Badly infested fields were plowed under and, where possible, seeded in a nonsusceptible crop.

In 1952, there was an outbreak of dwarf bunt, also called stinking smut, in oatgrass and wheatgrasses in Union County. The problem subsided when farmers avoided fall planting in bunt-infected areas.

Sod webworms were an annual problem in Union County (eastern Oregon) as well as in portions of the Willamette Valley. In 1946 and 1947, DDT was found to work well in killing the adult sod webworms but not the larvae. Later, lindane was found to be more effective on the larvae. The fungal disease *Beauveria globulifera* destroyed large populations of the worm in certain parts of western Oregon in 1950.

From 1945 to 1954, silvertop was found in grasses only in trace amounts, but in 1955, it destroyed about 2000 acres of Chewings fescue and seriously damaged Clackamas County crops. For many years, the exact nature of silvertop was not understood and it was mistakenly thought to be caused by mites. In fact, the real culprits were plant insects. DDT and field burning helped control silvertop; later, parathion replaced DDT for silvertop control.

Grass seed nematodes were a problem in bentgrass and fine fescues. Field burning, plowing, and crop rotation to a nonsusceptible crop were recommended.

Small amounts of 2,4-D ester were used on grass seed crops in 1946 and showed promise in controlling

St. Johnswort, field bindweed, and wild garlic. Later, 2,4-D use expanded to control other broadleaf weeds.

In 1949, a new pesticide, IPC (also known as Propham), was registered for use on grasses and legumes. It was the first soil active herbicide that had some selectivity as a grass killer and was effective against young seedling grasses. IPC was applied from 3 to 6 lb per acre in the fall when rain was expected, since it required water to move it into the root zone. However, if the weather became warm and dry, much of the IPC would volatilize. In the following decade, it was used extensively on perennial grasses and was preferred over Chloro IPC. IPC and Chloro IPC trials showed promise for control of annual grasses in clover when applied in February or March. Because CIPC manufacturing was discontinued for a time, Karmex DW began to replace CIPC for use on these crops:

- red fescue
- alta fescue
- bentgrasses
- bluegrasses
- alfalfa
- lotus

Regular IPC was better for treating other perennial grasses and Chewings fescue. A good burn on perennial grasses was necessary for the most effective use of soil active herbicides.

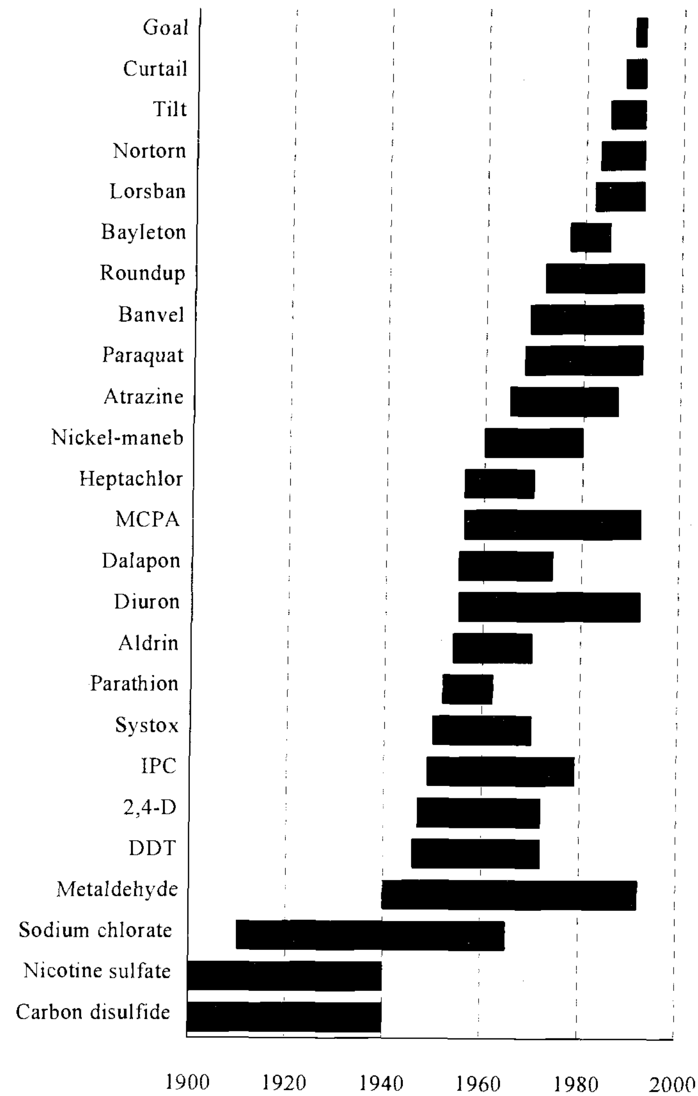
Karmex was an important new herbicide that was registered for use on grass seed crops in 1955. Fall applications of Karmex (diuron) controlled many grass and broadleaf seedlings in established grass field. This was an enormous step forward in weed control and is still the backbone of weed control in established fields.

Another new product, dalapon, applied at 20 to 30 lb per acre, was considered an excellent alternative to soil sterilants such as sodium chlorate. Spot treatments of amino triazole at 8 lb per acre controlled Canada thistle and quackgrass.

Simazine and atrazine looked promising for use on established perennial rye grasses in 1959. Fall application of diuron plus MCPA helped control sheep sorrel. Growers noted that using the same chemical every year in grass seed crops tended to favor buildup of resistant weed species. Brome species increased when only Karmex was used. IPC was used occasionally to reduce the buildup. With the use of new herbicides, the chief weed pests shifted slightly, and these became problem weeds:

- chess
- sheep sorrel
- buckhorn plantain
- Canada thistle
- quackgrass
- bluegrass

Figure 7. Prominent Pesticides Used on Grass Seed Crops with General Period of Use.



1960's

Each year, 15 to 20 percent of new grass seedbeds were plowed under because of poor stands caused by weed competition. As a result, more growers applied two fall herbicide treatments after the seed bed was prepared for spring planting (stale seed bed). Normally, 4 lb of IPC plus 1 lb of 2,4-D were applied in December. Just prior to seeding between February 15 and March 15, growers would treat all newly germinated weeds with 0.5 lb of paraquat. In the fall, growers applied 2 lb of diuron.

Perennial grass fields became increasingly weedy with stand age. Crop rotation helped prevent the buildup of troublesome weeds. Sodium chlorate had been used as a spot treatment to kill patches of these weeds, but by the early 1960's, atrazine was replacing it.

By the time field burning was an issue, these were the most troublesome:

- annual bluegrass
- rattail fescue
- Canada bluegrass
- downy brome
- velvetgrass
- quackgrass
- sheep sorrel
- curly dock
- buckhorn plantain
- Canada thistle
- wild garlic

The Oregon Seed Growers League stated that burning was the only practical method for controlling blind seed disease, ergot, and seed nematodes. They noted that the practice also aided control of silvertop, grass rust, and other diseases. Good field sanitation and fungicide applications reduced the prevalence of leaf and stem diseases. By 1964, field burning had become the single most important issue facing the grass seed industry. The practice of burning grass seed fields after harvest to control diseases originated in western Oregon. This practice enhanced weed control by destroying weed seeds and shattered crop seeds and removing crop residues.

During the 1960's, leaf rust and stem rust received more attention. Nickel sulfate-maneb mixture (Dithane S-31) was the most reliable chemical control of grass rust diseases.

By 1965, orchardgrass growers reported failing stands and reduced seed yields attributable to billbugs. Growers attempted to register 5 percent aldrin plus 10 percent diazinon for control. Sod webworms in orchardgrass were not as great a problem because of natural controls. Past studies showed that 91 percent of the webworms did not survive: birds consumed 80 percent; parasites, 8 percent; and 3 percent died of disease. Without these natural controls, bluegrass, fine fescues, and orchardgrass could not be grown in the Willamette Valley.

1970's

In 1970, activated charcoal was applied in the seed row for weed control. The diuron killed the weed seed between the rows, while the charcoal absorbed the diuron and protected the crop seed. Charcoal was first applied at about 300 lb per acre at a cost of $3 to $6 , depending upon row spacing.

Ergot, blind seed disease, grass seed nematode, and silvertop were well controlled by field burning. Leaf and stem diseases, however, were not well controlled by fire.

Table 5. Pesticide Use Comparisons for Oregon Grass Seed Crops, 1981, 1987, 1992.

Fungicides	**1981**	**1987**	**1992**
Chlorothalonil	5,000	63,000	28,000
Mancozeb	110,000	——	——
Maneb	——	250,000	——
Nickel sulfate	100,000	3,500	——
Propiconazole	——	36,000	52,000
Triadimefon	25,000	3,800	380
Sulfur	——	——	6,000
Herbicides	**1981**	**1987**	**1992**
2,4-D	83,000	104,000	98,000
Atrazine	95,000	220,000	3,600
Bromoxynil	3,000	9,600	7,800
Chlorpropham	20,000	——	——
Clopyralid	——	——	930
Dicamba	7,000	52,000	27,000
Diclofop methyl	——	120	——
Diuron	39,000	230,000	400,000
Ethofumesate	24,000	69,000	44,000
Fluazifop	——	1,600	——
Glyphosate	——	22,000	79,000
Metribuzin	——	——	11,000
MCPA	6,000	33,000	43,000
MSMA	12,000	5,300	——
Oxyflurofen	——	——	20,000
Paraquat	——	3,400	17,000
Propham	20,000	——	——
Sethoxydim	——	1,300	——
Simazine	——	86,000	——
Terbacil	——	4,300	——
Insecticides	**1981**	**1987**	**1992**
Carbaryl	——	2,200	——
Chlorpyrifos	——	37,000	18,000
Diazinon	10,000	10,000	——
Dimethoate	——	8,000	2,000
Fonofos	——	18,000	——
Metaldehyde	——	——	2,000
Parathion		30	——
Vertebrate Poisons	**1981**	**1987**	**1992**
Zinc phosphide	——	——	
Aluminum phosphide	——	——	
Strychnine alkaloid	——	——	

Nickel-maneb registration was canceled, but growers hoped to resurrect this Dithane S-31 label. Bayleton was being tested in 1976 as a replacement for Dithane S-31. Often, three or four treatments of Dithane S-31 at 4.5 lb per acre were applied, and control was often less than desirable. Stem rust in perennial ryegrass caused serious losses in 1977 (a drought year). Stripe rust was the main problem in Kentucky bluegrass crops.

Trials with Nortron showed promise for control of weedy grasses in annual and perennial ryegrass that were tolerant to Nortron. In the fall of 1975, 1000 gallons of Norton were applied (EUP) to control these weeds:

- rattail fescue
- annual bluegrass
- wild oats
- chess
- velvetgrass

Seed quality had increased in importance, and since many contaminating seeds could not be separated from the crop seed, it was important to control the undesirable weed species in the field. The grower's ability to control weed species determined whether or not the grower would survive economically. Weed control could fail for these reasons:

- nonuniform distribution of soil active herbicide
- poor herbicide absorption in crop residue
- weather conditions (IPC and CIPC work best during cool wet weather)
- physiological stage of weed
- weed tolerance to herbicide
- protracted germination of weeds over the winter
- emergence of different weed species at different times

It became increasingly important to control weeds at the time the grass seed fields were established. Ignored weeds tended to persist, resulting in poor crop seed quality.

Roughstalk bluegrass was a serious problem in perennial ryegrass fields, and control with available herbicides was not satisfactory. California brome herbicide tolerance was an increasing problem in tall fescue and orchardgrass, which were exceptionally tolerant to diuron and atrazine.

1980's

Wireworms, symphylids, and slugs were sporadic pest problems that destroyed grass seedlings from 1977 to 1979 and again from 1985 to 1987. Insecticide activity against cutworms, billbugs, and gelechiids was reduced by carbon residues from field burning.

Atrazine registration for perennial ryegrass seed was removed in the late 1980's. Atrazine had been a main component in perennial ryegrass production for about 20 years. Growers began using considerably more diuron since that time, but some weeds were more resistant to diuron.

Goal received a Section 18 registration for control of volunteer grass that germinated in unburned stands. This improved weed control for grasses tolerant to diuron.

This is an awkward time for grass seed growers. Field burning, which has been an important nonchemical control of weeds and diseases, is now limited by amount and by time. If a grower is given permission to burn a field, he may not be allowed to burn his field at the optimum time, resulting in crop damage and decreased yields. Burning the crop residue allows lower rates of soil applied herbicides. Fewer seedlings must be controlled after field burning sanitation. In addition, burning returns about $15 to $20 worth of fertilizer to the field (nitrogen, phosphorus, potassium). Straw removal, baling, and hauling is an additional expense borne by the grower. New cultural farming methods are needed to replace those methods practiced for 50 years. As a result of this confusion, every grower seems to be trying something different.

Linn, Lane, and Benton counties have large areas suitable only for grass seed production. Marion, Polk, and other more northern counties rotate a portion of their seed crop into vegetable and grain as a part of their cultural practices, but little crop rotation is possible in Linn and Benton counties. Grass stands do not remain in production as long as they have in the past. Annual bluegrass has become a more serious weed seed contaminant, especially in the southern Willamette Valley.

Boise Cascade Corporation has planted many acres of hybrid fast growing poplars in the southern Willamette Valley as a source of fiber for paper. Other uses, such as paper products, are being sought for the surplus straw that often is left to rot on the perimeter of the grass fields.

Diuron and atrazine were standard herbicides used in the past and were both economical and effective. When the atrazine registration was lost, growers depended more on diuron. Annual bluegrass was showing diuron resistance, but the subsequent Section 18 registration of Goal has helped control the bluegrass.

It is important that growers keep the density down on grass seed crops. Volunteer seed, scattered before and during harvest, will germinate and increase crop density. Stands become too thick for an optimum yield and may be rejected for certification because of the presence of "next generation" plants.

Diseases take time to build up in grass seed, and it is not yet clear what impact the changes in field burning and other practices will have on disease pressure.

The first statewide pesticide survey for Oregon included grass seed crops. Table 5 lists the amounts of pesticides applied to this crop for the 1981 survey and the subsequent 1987 and 1992 surveys.

Perennial Ryegrass

Pest Control Practices in the Year of Establishment

Ten to fifteen years ago, about half the growers used carbon planting when establishing a ryegrass field. Today, nearly all use this method of applying a slurry of activated charcoal in a 1-inch band above the seed to bind diuron and prevent it from killing the perennial ryegrass seedling. The remaining area between the seed rows, often 12 inches wide, is not protected by charcoal, and weed seeds germinating in this area are controlled. Carbon planting costs about $50 an acre for the carbon slurry and $15 for the diuron. Previously, field burning eliminated seed in the fields; but today, growers are plowing seeds deep into the soil and creating a source of unwanted weed seed. This weed seed bank will provide unwanted vegetation for many years to come. Grass stands used to last 4 or 5 years; today they last 3 years.

Metaldehyde bait is applied to the perimeter of some fields after crops are planted to prevent excessive damage to young seedlings when slugs migrate into the newly planted field. Repeated applications may be necessary in subsequent years.

After 3 or 4 inches of rain in the fall, Nortron is applied to all the fields to kill any germinating annual bluegrass at a cost of about $40 an acre. It is important to remove all the annual bluegrass because it is a turf weed. In much of the valley, there are no rotation crops that can be used to help control it. If the cost of control becomes unacceptable—perhaps $200 an acre—the land may be fallowed.

If the perennial ryegrass is planted in the spring in a stale seed bed (one that was prepared for planting in the fall), growers apply paraquat or Roundup prior to crop emergence to control seedling grasses and broadleaf weeds that germinate over the winter. If application is near the time of crop emergence or if rain is probable, paraquat is used.

The 1992 pesticide use estimates for perennial ryegrass seed are found in Table 6.

Pest Control Practices in an Established Planting

Preparing a perennial ryegrass field for a second or third year of production begins in August, right after the crop is combined. After baling and removing the straw, growers have three options: (1) vacuum up the loose grass and grass seed residue in the field with specialized vacuum machines, (2) propane burn the residues, or (3) flail the residue only. Occasionally, growers may do other things, such as pile the residues in rows with a needle nose rake.

The weed control program begins in October, but the herbicide chosen depends upon the type of weeds present in the field, the age of the stand, and whether sheep will graze on the grass during the fall and winter. Herbicide rates depend upon the vigor of the grass and the amount of crop residue left in the field.

Growers commonly apply a combination of Goal and diuron. A 1-year-old stand is vigorous and can tolerate the higher herbicide rates. If either annual ryegrass or California brome is a problem, a combination of Goal and Sencor (or Lexone) is applied. Whenever growers plan to pasture sheep, diuron and another herbicide are substituted for Goal. (Animals are not permitted to graze on grass treated with Goal.) The other herbicide applied may be Sencor (Lexone), Nortron, or atrazine, if an appropriately labeled atrazine product remains in the grower's inventory.

Grazing sheep on grass fields serves a dual purpose: it helps supplement income and improves the crop. Growers charge a grazing fee. Sheep grazing increases tillering, which, in turn, increases seed production. Grazing removes old and new foliage, which serve as disease hosts. This increases the strength of the stand.

After harvest, a lot of seed is left on the soil surface. This grass seed must not be allowed to become established. Emergence is protracted over the fall and winter, and a second herbicide application is necessary in December or January, before these new seedling grasses and weeds become established. In December, growers normally repeat applications of Goal and diuron. A total of 30 ounces per acre of Goal and 2 lb of diuron are allowed per season. If that rate would be exceeded by additional applications of Goal, the grower will apply only diuron. If the stand is weak, growers will apply Goal alone in the fall, followed by diuron treatment in December. Both are applied at reduced rates.

In January, Nortron can be applied to control annual bluegrass and is more commonly used in the south Willamette Valley than the north. Because Nortron is expensive, growers are reluctant to spray unless they know that the crop will not be certified because of annual bluegrass seed contamination.

Between February 15 and March 15, nearly all fields in Lane, Linn, and Benton counties are treated once with 2,4-D ester and Banvel, often in combination with liquid fertilizer. Fertilizer is commonly applied in three applications totaling about 130 to 145 lb of nitrogen. If the pH is too low, 2 tons of lime are applied at $80 an acre. MCPA is applied instead of 2,4-D ester in Marion and Yamhill counties because neighboring ornamental nurseries are susceptible to injury from 2,4-D drift. Buctril, Curtail, and Stinger are occasionally applied. Curtail M was still registered for the 1993 season, although it was no longer manufactured.

In the spring, rust diseases are an annual problem in grass seed crops. Two schemes are employed by growers to control stripe rust. Some may apply Tilt on a calendar schedule, starting 9 weeks before harvest. However, most have agricultural consultants scout their fields and apply Tilt when rust appears. Most growers apply 12 to 18 ounces per acre over two or three applications. Occasionally, four applications are necessary. This is expensive, costing an average of $43 per acre per year. Nickle-maneb (Dithane S-31) was used in the past, but it is no longer registered and was only marginally effective. Bayleton, which is registered for rust, is less effective, and very few growers use it.

During the year, some spot spraying with Roundup for perennial ryegrass off-types and other grasses helps keep the harvested seed low in foreign seed, which lowers quality.

When mice are troublesome, zinc phosphide treated bait is applied. Gophers, if present, are trapped or holes are treated with phostoxin. Some growers may also burn sulfur with a propane torch and direct the fumes into the runs, asphyxiating gophers.

Annual Ryegrass

Pest Control Practices

Annual ryegrass, as the name suggests, is newly planted each year. In most instances, it is planted in a field that has been in grass seed production. Planting is accomplished normally in one of three ways: (1) the residual straw from the previous harvest is flailed, and the ground is plowed and prepared for drilling seed in September; (2) the straw residue is burned, and the field is planted using no-till practice; or (3) the residue straw is flailed twice, producing a finely cut straw, and the annual ryegrass is allowed to volunteer. This third method is experimental and can be done only once or twice on a weed-free field before plowing is necessary.

About once every 3 years, Nortron is applied to control rattail fescue, annual bluegrass, manograss, and other grasses. Nortron costs between $30 and $45 an acre, and because of the expense, growers try to limit their use of this pesticide. Nortron is important because it greatly reduces most competing seedling grasses which, if allowed to produce seed, will contaminate the seed crop at harvest.

The following spring, two applications of fertilizer (120 lb nitrogen total) are applied. Most growers apply 2,4-D ester in the spring for broadleaf weed control.

During the year, some spot spraying with Roundup is done to control perennial ryegrass and off-types and other grasses. This practice helps keep the harvested seed low in foreign seed, which lowers quality.

When mice are troublesome, zinc phosphide treated bait is applied. Gophers, if present, are either trapped or holes are treated with phostoxin. Some growers may also burn sulfur with a propane torch and direct the fumes into the runs. Gophers are asphyxiated.

The 1992 pesticide use estimates for the annual ryegrass seed crop are listed in Table 7.

Tall Fescue

Pest Control Practices

The year of establishment of tall fescue is very similar to perennial ryegrass that is seeded in the fall. When it is planted in the spring, carbon planting is not used. The stale seedbed is treated with Roundup to eliminate the weed flush.

In an established tall fescue grass seed field, most of the tall fescue hay is baled and removed, and the field is flailed to knock down the grass bunches or remaining straw. A few growers do not bale the straw but chop it back onto the field. With the field prepared, herbicides are applied. Tall fescue has a higher tolerance for herbicides than many other grass seed crops and, when necessary, higher application rates can be used. Atrazine and diuron were the standard treatment until the atrazine registration was lost. Today, fall herbicide treatment can begin with one application of diuron in October, followed by a second diuron treatment in December. An alternative treatment is an application of Goal and Sencor or diuron at the first rain. Fields are treated again in December with an application of diuron. The choice of methods depends upon the weed complex. Nortron is occasionally used to control California brome.

About half the acres are treated in the spring with 2,4-D and Banvel. MCPA, Buctril, and Curtail are not used.

Because rust is not a consistent problem, tall fescue receives no treatment of Tilt in some years; in other years, half the acres are treated. In 1992, about a quarter of the fields were treated. Sheep grazing over the fall and winter helps reduce rust incidence by eliminating excess foliage, which acts as a disease host.

Slugs are a minor problem and only a few fields are treated with metaldehyde baits. Mice and symphylans are occasional pests on fescue.

The 1992 pesticide use estimates for tall fescue grass seed are found in Table 8.

Orchardgrass

Pest Control Practices

Orchardgrass establishment is similar to seeding perennial ryegrass in the fall. When planted in the spring, carbon planting is not used. The stale seedbed is treated with Roundup to eliminate the weed flush.

Preparing an orchardgrass field for production is less complicated than the preparation for most other grasses. Most of the orchardgrass is baled and removed, and the fields are flailed to knock down the grass bunches or remaining straw. A few growers do not bale the straw but chop it back onto the field.

Orchardgrass has a high tolerance for herbicides and, when necessary, higher application rates of herbicides can be used. Atrazine and diuron were the standard treatment until the atrazine registration was lost. Today, fall herbicide treatment can start with one application of diuron in October, followed by a second diuron treatment in December. An alternative treatment is an application of Goal and Sencor at the first rain. Fields are treated again in December with an application of diuron. The choice of methods depends upon the weed complex. Nortron is occasionally used to control California brome.

Less nitrogen is applied to orchardgrass than other grasses. If excessive nitrogen is applied to orchardgrass, the grass becomes rank (grows vigorously) and falls over in the rain or wind (lodging). If the grass is rank, it becomes more susceptible to disease—such as rust—because less air flows through the stands.

Billbugs, an insect peculiar to orchardgrass, are controlled with Lorsban as soon as the bugs become active early in the spring. If timely treatments are not made, the billbugs will take a stand out of production. To be effective, Lorsban needs to be watered in.

When the grass is beginning to form a seed head, Bravo 720 treatments are applied to control leaf diseases. About half the fields receive two or more fungicide treatments. Orchardgrass is first treated when the flag leaf and head just start showing and is treated a second time at full head. In a bad year, yields can drop 30 percent because of disease. Leaf diseases were less severe in 1992 because the weather was dry and leaf diseases thrive under wet and cool climatic conditions. Rust, which develops better in hot, dry weather, was more of a problem in the Willamette Valley in 1992, a hot, dry year.

The 1992 pesticide use estimates for orchardgrass seed are found in Table 9.

Bluegrass

Pest Control Practices in the Year of Establishment

Most of the bluegrass is grown in Jefferson County or central Oregon, with lesser amounts in Union, Umatilla, Marion, and other counties. In a normal year, about 20 percent of the crop is new planting, but in the drought years of 1991 and 1992, new plantings were down to about 10 percent, resulting in fewer acres of plantings. The drought reduced the amount of water available in central Oregon, and about 40 percent of the land was not irrigated, but was fallow. The year 1993 was a wet year with adequate irrigation water in the reservoir.

Kentucky bluegrass and rough bluegrass are planted by August 15 or later and are kept in a 4- to 5-year rotation with such crops as wheat, potatoes, mint, and other seed crops. After seedbeds are prepared, Gramoxone or Roundup are applied, primarily to kill germinating annual weeds. Seed is planted shortly afterward. Generally, after the grass has germinated and toward the end of September, Buctril or sometimes Buctril plus MCPA is applied for broadleaf weed control. If weeds persist in the fall, especially in rough bluegrass, Gramoxone or sometimes Roundup spray is directed between the grass rows. The grass row is shielded from the herbicide by metal panels on either side of the nozzles. In the spring, Gramoxone may be applied by the same method.

Most growers apply 2,4-D LV ester plus Banvel in the spring. If weather is warm, 2,4-D amine is applied instead of the ester.

Thiosol, sulfur combined with liquid fertilizer, is often applied in late April or early May for mildew control. Other growers apply Bayleton or Tilt for mildew and rust. Mildew seems to be increasing in the past few years, and new plantings tend to be more susceptible to the disease. Another disease, ergot, has no chemical controls.

Fields are cut at the end of June and combined with a harvester when dry. Growers burn the fields in August under rules set forth by the Smoke Management Program.

Table 10 shows the pesticide use estimates for Oregon bluegrass seed crops.

Pest Control Practices in an Established Planting

Once a planting is established, chemical treatments are different. Following burning, land is harrowed and watered. Annual grasses that were not adequately controlled in the first year must be controlled in the second year. High rates of Banvel, up to 5 pints per acre, are applied and watered in. Insufficient watering in warm weather allows Banvel to vaporize; too much water moves it through and out of the root zone. Downy brome and rattail fescue are the chief grassy weeds. Diuron is also used, especially when rattail fescue is a major problem. Furrow irrigation is used in central Oregon, and as a result, carbon banding is not practiced. Water, under furrow irrigation practice, will move up through the soil carrying herbicides into the seeded area. Because the carbon is above the seed, it will be of little value in binding diuron before it reaches the grass seed. Sencor was not registered for grass seed crops in Jefferson County. However, some Goal is used.

During the winter, a few growers apply Lorsban to control outbreaks of glassy cutworm. More growers treat for winter grain mites with dimethoate. This pest is carefully monitored to determine whether spraying is needed.

In the spring, 2,4-D plus Banvel is applied for broadleaf weed control. Thiosol is applied for mildew and either Tilt or Bayleton for rust. Growers alternate between Tilt and Bayleton to minimize fungicide resistance in rust. Grass is cut and combined to complete an established year.

Table 6. **Pesticides Use Estimates for Oregon Perennial Ryegrass Seed Crop, 1991-1992. 112,980 acres harvested, 1992.**

Common Name	Trade Name	Rate of Application	Method of Application	Acres Treated	Pounds Used a.i.
EARLY FALL - carbon planting					
>>>>>>>Weeds: seedling broadleaf and grass					
Diuron	Karmex 80W	3.0 lb/acre	soil	32,000 (29%)	77,000
	Diuron 4L	2.4 qt/acre			
FALL - preemergence					
>>>>>>>Weeds: germinating weeds					
Paraquat	Gramoxone	1.5 pt/acre	foliar	5,500 (05%)	4,200
Glyphosate	Roundup	1.5 pt/acre	foliar	2,700 (02%)	2,100
FALL - new plantings					
>>>>>>>Weeds: annual bluegrass					
Ethofumesate	Nortron SC	1.0 qt/acre	soil	32,000 (28%)	12,000
>>>>>>>Pests: slugs					
Metaldehyde bait	Deadline	30 - 60 lb/acre	field perimeter	5,600 (05%)	5,600
	Metaldehyde 4 Bait				
OCTOBER - established plantings					
>>>>>>>Weeds: annual bluegrass, rattail fescue, volunteer cereals, wild oats					
Oxyfluorfen (Sec 18)	Goal 1.6E	16 - 20 oz/acre	soil	41,600 (37%)	8,320
Metribuzin	Sencor DF, Lexone	0.25 - 0.5 lb/acre	soil	13,000 (11%)	3,600
Ethofumesate	Nortron SC	1.5 - 2.0 pt/acre	soil	3,500 (03%)	980
Diuron	Diuron 80W	1.25 - 1.5 lb/acre	soil	62,000 (55%)	62,000
Atrazine	remaining stocks	1.5 lb/acre	soil	3,000 (03%)	3,600
DECEMBER - established plantings					
>>>>>>>Weeds: broadleaf weeds and grasses					
Diuron	Karmex 80W	0.75 - 1.5 lb/acre	soil	70,000 (62%)	62,000
Metribuzin	Sencor DF, Lexone	0.25 - 0.5 lb/acre	soil	5,800 (05%)	1,600
Oxyfluorfen (Sec 18)	Goal 1.6E	4 - 10 oz/acre	soil	16,600 (15%)	1,660
JANUARY -established plantings					
>>>>>>>Weeds: annual bluegrass					
Ethofumesate	Nortron SC	1.0 qt/acre	soil	23,000 (20%)	8,400
SPRING - stale seedbed					
>>>>>>>Weeds: germinating weeds, winter annuals					
Paraquat	Gramoxone	1.5 pt/acre	foliar	2,400 (02%)	1,800
Glyphosate	Roundup	1.5 pt/acre	foliar	2,400 (02%)	1,800
SPRING					
>>>>>>>Weeds: broadleaf weeds					
2,4-D ester (6 lb/gal)		0.75 pt/acre	foliar	78,000 (69%)	39,000
Dicamba	Banvel	4.0 oz/acre	foliar	91,000 (81%)	11,000
MCPA (4 lb/gal)		1.0 pt/acre	foliar	33,000 (29%)	16,000
Bromoxynil	Buctril	24 oz/acre	foliar	5,100 (05%)	2,000
Clopyralid	Curtail, Stinger	2.0 - 4.0 pt/acre	foliar	6,600 (06%)	940

Table 6. Continued.

Common Name	Trade Name	Rate of Application	Method of Application	Acres Treated	Pounds Used a.i.
MAY					
>>>>>>>Diseases: rust					
Propiconazole	Tilt	4.0-6.0 oz/acre	foliar	113,000 (100%)	16,000
JUNE					
>>>>>>>Diseases: rust					
Propiconazole	Tilt	4.0-6.0 oz/acre	foliar	113,000 (100%)	16,000
JULY					
>>>>>>>Diseases: rust					
Propiconazole	Tilt	4.0-6.0 oz/acre	foliar	56,000 (50%)	7,900
SPRING & SUMMER					
>>>>>>>Weeds: annual grasses, volunteer seed crop					
Glyphosate	Roundup	2% solution	spot treatment	11,000 (10%)	11,000
>>>>>>>Pests: mice					
Zinc phosphide	field mouse bait	6 - 10 lb/acre	runs	5,600 (05%)	680
>>>>>>>Pests: gophers					
Aluminum phosphide	Phostoxin	5 - 20 pellets/burrow		3,400 (03%)	16
Strychnine alkaloid	gopher bait	1 tbsp/burrow		1,100 (01%)	5

Table 7. **Pesticides Use Estimates for Oregon Annual Ryegrass Seed Crop, 1991-1992. 117,000 acres harvested, 1992.**

Common Name	Trade Name	Rate of Application	Method of Application	Acres Treated	Pounds Used a.i.
OCTOBER					
>>>>>>>Weeds: annual bluegrass, rattail fescue, volunteer cereals, wild oats					
Ethofumesate	Nortron SC	1.5 - 2.0 pt/acre	soil	30,000 (26%)	8,600
>>>>>>>Pests: slugs					
Metaldehyde bait	Metaldehyde 4 Bait, Deadline		field perimeter	5,900 (05%)	7,000
SPRING					
>>>>>>>Weeds: broadleaf weeds					
2,4-D ester (6 lb/gal)		0.75 pt/acre	foliar	77,000 (66%)	39,000
MCPA (4 lb/gal)		1.0 pt/acre	foliar	21,000 (18%)	10,000
Dicamba		4.0 oz/acre	foliar, soil	91,000 (78%)	11,000
SPRING & SUMMER					
>>>>>>>Weeds: perennial grasses, volunteer grains					
Glyphosate	Roundup	2% solution	spot treatment	12,000 (10%)	12,000
>>>>>>>Pests: Mice					
Zinc phosphide	field mouse bait	6 - 10 lb/acre	mouse runs	5,900 (05%)	700
>>>>>>>Pests: gophers					
Aluminum phosphide	Phostoxin	5 - 20 pellets/burrow		3,500 (03%)	17
Strychnine alkaloid	gopher bait	1 tbsp/burrow		1,200 (01%)	6

Table 8. Pesticides Use Estimates for Oregon Tall Fescue Seed Crop, 1991-1992. 85,290 acres harvested, 1992.

Common Name	Trade Name	Rate of Application	Method of Application	Acres Treated	Pounds Used a.i.
EARLY FALL - carbon planting					
>>>>>>>Weeds: seedling broadleaf and grass					
Diuron	Karmex 80W	3.0 lb/acre	soil	20,000 (23%)	47,000
	Diuron 4L	2.4 qt/acre			
FALL - preemergence					
>>>>>>>Weeds: germinating weeds					
Paraquat	Gramoxone	1.5 pt/acre	foliar	4,500 (05%)	3,400
Glyphosate	Roundup	1.5 pt/acre	foliar	3,800 (04%)	2,900
FALL - new plantings					
>>>>>>>Weeds: annual bluegrass					
Ethofumesate	Nortron SC	1.0 qt/acre	soil	18,000 (22%)	6,900
>>>>>>>Pests: slugs					
Metaldehyde bait	Deadline	30 - 60 lb/acre	field perimeter	8,300 (10%)	1,600
	Metaldehyde 4 Bait				
OCTOBER - established plantings					
>>>>>>>Weeds: annual bluegrass, rattail fescue, volunteer cereals, wild oats					
Oxyfluorfen (Sec 18)	Goal 1.6E	16 - 20 oz/acre	soil	34,800 (41%)	6,960
Metribuzin	Sencor DF, Lexone	0.25 - 0.5 lb/acre	soil	16,000 (19%)	4,600
Diuron	Diuron 4L	2.0 - 3.0 pt/acre	soil	45,000 (53%)	55,000
DECEMBER - established plantings					
>>>>>>>Weeds: broadleaf weeds and grasses					
Diuron	Diuron 4L	1.5 - 3.0 pt/acre	soil	41,000 (49%)	36,000
JANUARY -established plantings					
>>>>>>>Weeds: annual bluegrass					
Dicamba	Banvel	8 - 16 oz/acre	foliar	11,000 (13%)	4,300
Ethofumesate	Nortron SC	1.0 qt/acre	soil	15,000 (17%)	5,200
SPRING - new plantings					
>>>>>>>Weeds: germinating weeds, winter annuals					
Paraquat	Gramoxone	1.5 pt/acre	foliar	1,300 (01%)	950
Glyphosate	Roundup	1.5 pt/acre	foliar	14,000 (16%)	10,000
SPRING					
>>>>>>>Weeds: broadleaf weeds					
2,4-D ester (6 lb/gal)		0.75 pt/acre	foliar	26,000 (31%)	13,000
Dicamba	Banvel	4.0 oz/acre	foliar	49,000 (58%)	6,000
MCPA (4 lb/gal)		1.0 pt/acre	foliar	29,000 (34%)	14,000
JUNE					
>>>>>>>Disease: rust					
Chlorothalonil	Bravo 720	1.5 - 3.0 pt/acre	foliar	1,900 (02%)	1,900
Propiconazole	Tilt	4.0 - 6.0 oz/acre	foliar	65,000 (77%)	9,100

Table 8. Continued.

Common Name	Trade Name	Rate of Application	Method of Application	Acres Treated	Pounds Used a.i.
SPRING & SUMMER					
>>>>>>>Weeds: annual grasses, volunteer seed crop					
Glyphosate	Roundup	2% solution	spot treatment	8,300 (10%)	8,300
>>>>>>>Pests: mice					
Zinc phosphide	field mouse bait	6 - 10 lb/acre	runs	4,100 (05%)	500
>>>>>>>Pests: gophers					
Aluminum phosphide	Phostoxin	5 - 20 pellets/burrow		2,500 (03%)	12
Strychnine alkaloid	gopher bait	1 tbsp/burrow		830 (01%)	4

Table 9. Pesticides Use Estimates for Oregon Orchardgrass Seed Crop, 1991-1992. 18,700 acres harvested, 1992.

Common Name	Trade Name	Rate of Application	Method of Application	Acres Treated	Pounds Used a.i.
EARLY FALL - carbon planting					
>>>>>>>Weeds: seedling broadleaf and grass					
Diuron	Karmex 80W	3.0 lb/acre	broadcast	4,200 (23%)	10,000
	Diuron 4L	2.4 qt/acre			
Ethofumesate	Nortron SC	1.0 qt/acre	soil	3,900 (21%)	1,500
FALL - preemergence					
>>>>>>>Weeds: germinating weeds					
Glyphosate	Roundup	1.5 pt/acre	foliar	640 (03%)	480
Paraquat	Gramoxone	1.5 pt/acre	foliar	320 (02%)	240
OCTOBER - established plantings					
>>>>>>>Weeds: annual bluegrass, rattail fescue, volunteer cereals, wild oats					
Oxyfluorfen (Sec 18)	Goal 1.6E	16 - 20 oz/acre	soil, broadcast	7,000 (37%)	1,400
Metribuzin	Sencor DF, Lexone	0.25 - 0.5 lb/acre	soil, broadcast	4,300 (23%)	1,200
Diuron	Diuron 4L	2.0 - 3.0 pt/acre	soil, broadcast	8,900 (48%)	11,000
DECEMBER - established plantings					
>>>>>>>Weeds: broadleaf weeds and grasses					
Diuron	Diuron 4L	1.5 - 3.0 pt/acre	soil, broadcast	9,800 (53%)	8,800
JANUARY -established plantings					
>>>>>>>Weeds: annual bluegrass					
Dicamba	Banvel	8 - 16 oz/acre	foliar	3,200 (17%)	1,200
Ethofumesate	Nortron SC	1.0 qt/acre	soil	660 (04%)	250
SPRING - new plantings					
>>>>>>>Weeds: germinating weeds, winter annuals					
Glyphosate	Roundup	1.5 pt/acre	foliar	3,600 (19%)	2,800
Paraquat	Gramoxone	1.5 pt/acre	foliar	320 (02%)	240

Table 9. Continued.

Common Name	Trade Name	Rate of Application	Method of Application	Acres Treated	Pounds Used a.i.
SPRING					
>>>>>>>Weeds: broadleaf weeds					
2,4-D ester (6 lb/gal)		0.75 pt/acre	foliar	6,600 (36%)	3,300
Dicamba	Banvel	4.0 oz/acre	foliar	10,000 (56%)	1,300
MCPA (4 lb/gal)		1.0 pt/acre	foliar	5,100 (27%)	2,500
>>>>>>>Insects: billbugs					
Chlorpyrifos	Lorsban 4E	1.0 qt/acre	soil	16,000 (88%)	16,000
MAY					
>>>>>>>Disease: leaf diseases					
Chlorothalonil	Bravo 720	1.5 - 3.0 pt/acre	foliar	12,000 (65%)	15,000
JUNE					
>>>>>>>Disease: rust					
Chlorothalonil	Bravo 720	1.5 - 3.0 pt/acre	foliar	12,000 (65%)	12,000
Propiconazole	Tilt	4.0 - 6.0 oz/acre	foliar	6,400 (34%)	890
SPRING & SUMMER					
>>>>>>>Weeds: annual grasses, volunteer seed crop					
Glyphosate	Roundup	2% solution	spot treatment	1,800 (10%)	1,800
>>>>>>>Pests: mice					
Zinc phosphide	field mouse bait	6 - 10 lb/acre	runs	920 (05%)	110
>>>>>>>Pests: gophers					
Aluminum phosphide	Phostoxin	5 - 20 pellets/burrow		550 (03%)	3
Strychnine alkaloid	gopher bait	1 tbsp/burrow		180 (01%)	1

Table 10. Pesticides Use Estimates for Oregon Bluegrass Seed Crops, 1991-1992. 20,150 acres Kentucky bluegrass harvested, 1991.

Common Name	Trade Name	Rate of Application	Method of Application	Acres Treated	Pounds Used a.i.
AUGUST - new plantings					
>>>>>>>Weeds: germinating weeds					
Glyphosate	Roundup	1.0 qt/acre	foliar	16,000 (80%)	16,000
Paraquat	Gramoxone	1.0 qt/acre	foliar	4,000 (20%)	4,000
FALL - new plantings					
>>>>>>>Weeds: broadleaf weeds					
Bromoxynil	Buctril	24 oz/acre	foliar	16,000 (80%)	6,100
MCPA		1.0 - 1.5 pt/acre	foliar	2,000 (10%)	1,000
>>>>>>>Weeds: broadleaf weeds and grasses					
Paraquat	Gramoxone	1.0 qt/acre	shielded spray	2,000 (10%)	2,000
Glyphosate	Roundup	1.0 qt/acre	shielded spray	2,000 (10%)	2,000
FALL - established plantings					
>>>>>>>Weeds: annual grasses, cheatgrass, rattail fescue					
Dicamba	Banvel	5.0 pt/acre	foliar	6,000 (30%)	740
Diuron	Diuron 4L	2.0 - 3.0 pt/acre	soil	16,000 (80%)	16,000
Oxyfluorfen (Sec 18)	Goal 1.6E	16 - 20 oz/acre	soil	2,000 (10%)	2,000
WINTER - established plantings					
>>>>>>>Insect: glassy cutworm					
Chlorpyrifos	Lorsban 4E	1.0 qt/acre	foliar	2,000 (10%)	2,000
>>>>>>>Insect: winter grain mite					
Dimethoate	Dimethoate 267	1.5 pt/acre	foliar	4,100 (20%)	2,000
SPRING					
>>>>>>>Weeds: broadleaf weeds					
2,4-D LV ester or amine	(4 lb/gal)	1.0 - 1.5 pt/acre	foliar	16,000 (80%)	8,000
MCPA		1.0 - 1.5 pt/acre	foliar	2,000 (10%)	1,000
Dicamba	Banvel	4.0 oz/acre	foliar	16,000 (80%)	1,900
>>>>>>>Weeds: winter annuals					
Paraquat	Gramoxone	1.0 qt/acre	shielded spray	2,000 (10%)	2,000
Glyphosate	Roundup	1.0 qt/acre	shielded spray	2,000 (10%)	2,000
MAY					
>>>>>>>Diseases: mildew, rust					
Sulfur plus fertilizer	Thiosol		foliar	2,000 (10%)	6,000
Propiconazole	Tilt	4.0 - 6.0 oz/acre	foliar	2,000 (10%)	280
Triadimefon	Bayleton	4.0 - 8.0 oz/acre	foliar	2,000 (10%)	380
ALL YEAR					
>>>>>>>Weeds: off-type grasses, noxious weeds					
Glyphosate	Roundup	1.0 qt/acre	spot spray	10,000 (50%)	1,000

Legume Seed Crops

Production

Alfalfa was grown for seed prior to 1900, but major commercial production actually started in 1937, when over a million pounds of clean seed were produced. Seed production has fluctuated widely ever since. By 1992, nearly all of the alfalfa seed was grown in Malheur, Umatilla, and Gilliam counties.

Red clover, one of the earliest legume crops introduced in Oregon, was grown as early as 1854. Production remained small until 1921, when one and a half million pounds were produced. Crimson clover was also a pioneer seed crop. Alsike, arrowleaf, white, ladino, and other clovers have a small production. Most clover is grown in the northwestern counties of the Willamette Valley.

Vetches were first introduced in Oregon in 1870, but seed was not commonly harvested until after the turn of the century. Production has fluctuated widely since then. Figures 8, 9, and 10 show the annual acreage, production, and yield of legume seed crops.

Historical Pesticide Use in Legume Seed Crops

Early this century, the legume diseases stem rot and leaf spot were seldom problems, but insects were. Sometimes aphids would escape from the control of natural predators, such as ladybugs and syrphid flies, and seriously injure legume crops. This occurred in 1912 and 1918 when there was no adequate means of control, and these pests nearly destroyed the vetch crop. The major nonchemical control was to cut the crop while it could still be used as forage, or if the crop was not large enough, it was used as pasture. Although pesticide use on legume seed crops was limited, in the years that followed it became more common to treat the crop. Table 11 lists some of the pesticides important to legume seed production. This is not an inclusive list but instead shows which pesticides were predominately used, not just available.

By the mid-1930's, dinitro-creosol (Sinox) became available. It had previously been used in large quantities by the dye industry, but in 1937 it was introduced into the

Figure 8. Annual Acres of Oregon Legume Seed Crops, 1880-1992.

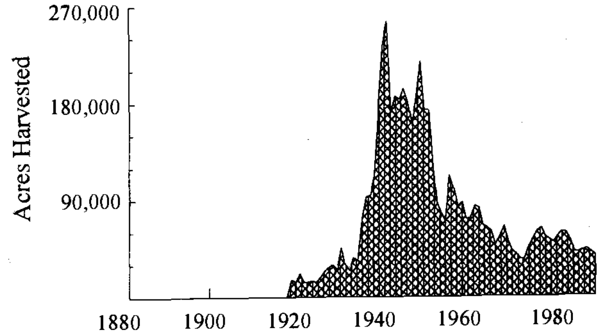


Figure 9. Annual Production of Oregon Legume Seed, 1880-1992.

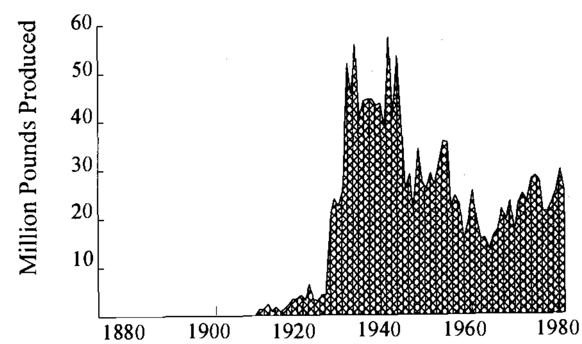
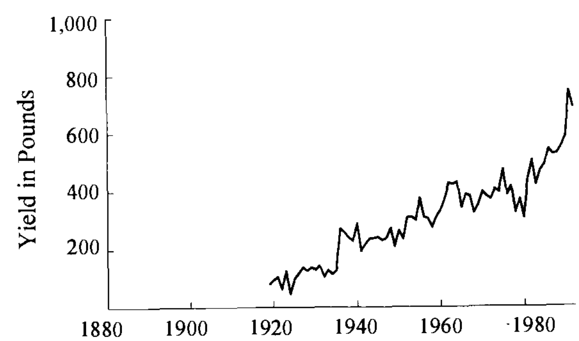


Figure 10. Annual Average Yield of Oregon Legume Seed Crops, 1880-1992.



* Information compiled from Seed Crops, USDA Bureau of Agricultural Economics, 1939-51; Seed Crops, USDA Agricultural Marketing Service, CRB, 1952-60; Seed Crops, USDA SRS, Crop Reporting Board, 1960-76; Seed Crops, USDA ESCS, Crop Reporting Board, 1977-80; Extension Economic Information Office, OSU, 1981-92.

1930's

United States (from France) as the herbicide Sinox (dinitro-o-cresylate). Its herbicidal properties were enhanced with the addition of ammonium sulfate, and it was used to remove weeds in seedling alfalfa, clover, and vetch. Sinox was especially effective in controlling broadleaf plants such as mustard. Nonchemical weed control was obtained by planting companion crops such as vetch and oats. These crops could suppress Canada thistle and other persistent perennial weeds.

Although common in the area, slugs were a new pest to legume crops, and growers attempted to control them with copper sulfate. However, by the mid 1930's, slugs were increasing at such an alarming rate that they were a serious threat to clover and vetch seed stands. Clover and vetch sustained injury in the spring, after the slugs hatched. The most effective control was metaldehyde bait applied in March or April when the eggs hatched. Today, fall treatments of metaldehyde are considered superior to spring treatments. Metaldehyde baits, first available about 1940, originally were formulated with calcium arsenate as a supplemental toxin.

Nematode damage became increasingly evident, but no chemical controls were employed. Other insect pests were the 12-spotted beetle, clover leaf curculio, clover leaf weevil, and nitidulid beetles.

In the 1940's, the hairy vetch weevil became the greatest insect threat to legume crops. Before World War II, growers used limited dusting with arsenates or pyrethrums. These controlled about 60 percent of the adult weevil population, but the cost was prohibitive.

Post War

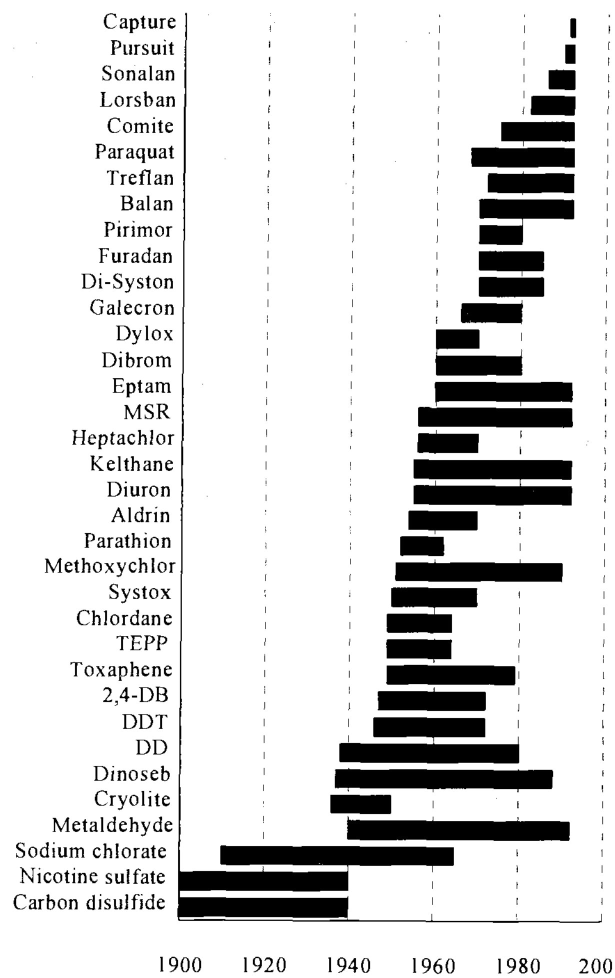
After the war, growers discovered that if they applied a thorough dusting of DDT when the pods first appeared, they could control the hairy vetch weevil. This was the first good control of the weevil, and DDT replaced the older dusts. The clover seed weevil, first found in the Pacific Northwest in 1929, became a serious pest in clovers. Growers used DDT, chlordane, and toxaphene to combat this pest, as well as the pea aphid, vetch weevil, alfalfa weevil, and Lygus bug, but could not control the clover seed chalcid nor the seed midge. However, at the same time, some were concerned that these pesticides might be stored in the fat tissues of grazing animals and be found in milk. As a result, feeding restrictions were placed on forage crops treated with these chemicals.

Studies showed that Lygus bugs were seriously affecting clover and alfalfa seed yields. Test plots at the Southern Oregon Experiment Station correlated large increases in ladino clover seed yield with timely applications of DDT for Lygus bug control. Dusting was done early in the morning before bees began flying. DDT dust was increasingly used thereafter to control this pest. It was applied to alfalfa before the crop bloomed because of the danger of killing bees. Lygus bugs and pea aphids were the major insect problems on the alfalfa seed crop, but with the advent of DDT and toxaphene, and then a few years later, parathion and Systox, control was maintained. Systox was the preferred treatment whenever aphids were a problem.

Red spiders and aphids limited red clover seed production in Malheur County. Indiscriminate use of DDT, TEPP, and parathion often upset the aphid predator and mite predator balance; low yields were often attributed to this mite-aphid imbalance, as well as other poor insect management techniques such as spraying during bloom.

Growers understood that an adequate number of pollinating insects was the key factor in seed production, and from 1947 to 1957, the number of bee colonies used for the pollination of legume crops increased a hundredfold.

Figure 11. Prominent Pesticides Used on Legume Seed Crops with General Period of Use.



One of the greatest hazards to the seed producer was the killing of the pollinators by indiscriminate application of insecticides, since not all growers followed the recommendations for applying pesticides. By moving the insecticide application time to the early evening hours, bee kills were reduced as much as 25 percent.

Clover root curculio, which infested clover roots, was one of the major causes for decline of alsike clover stands in Oregon. Heptachlor effectively controlled the larvae.

MCPA, first registered as MCP, was found to be an effective broadleaf killer in red clover. This was especially important for suppression of dock or sorrel.

1960's

The methods of establishing legume seed crops changed during the 1960's when new herbicides became available. When Eptam was registered in the early 1960's, it became the standard preemergence herbicide treatment, just as it is today. It was an important method of weed control while the legumes were small. Diuron was useful, but could not be applied until the crop was well rooted.

The alfalfa seed crop was traditionally planted by broadcasting the seed; however, soil active herbicides that could be applied in strips made planting in rows more attractive. Banding soil active herbicides when the crop was planted eliminated many weeds in the seed row. An additional one or two cultivations controlled weeds between the rows.

Several noxious weeds had always been serious problems in alfalfa seed fields in Malheur County, located in eastern Oregon. No adequate chemical controls had existed for quackgrass, crabgrass, or Canada thistle until Roundup was registered in the mid-1970's. Dodder, a parasitic viny weed, was controlled with CIPC or Casoron until they were replaced by Prowl about a dozen years later. Noxious weed seed, such as dodder, contaminated alfalfa seed, rendering the crop worthless, because the tolerance for this weed seed was zero.

With the advent of Treflan use, blackleaf nightshade and some cutleaf nightshade that were tolerant to Treflan became serious problems at harvest. In order to maintain control, growers applied a limited amount of 2,4-DB and, with correct timing, could control the nightshades very well. Many of the annual grasses were controlled by Treflan application.

Traditionally, the alfalfa seed crop was cut with a swather and allowed to dry in the field. Defoliants were applied to aid in harvesting some clovers and alfalfa. Growers applied about 2 pints of Dinitro General in 10 gallons of diesel fuel, and this practice gained acceptance in the early 1950's. The first attempts to desiccate the fields with two applications of endothall were not very successful. Des-I-Cate worked better, but Dinitro became the standard treatment until Diquat was registered in the mid-1960's. Chemically defoliating alfalfa was expensive and not always successful. Rank alfalfa was not easily killed.

The leaf cutter bee and alkali bee were discovered to be important pollinators for the alfalfa seed crop. DDT and toxaphene were so hard on these pollinators, that in at least one region of Malheur County, growers formed a spray district, making it illegal to apply either insecticide. As a result, growers switched to Dibrom, Phosdrin, Dylox, and Systox. Bee kills declined rapidly.

1970's

The combination of parathion and toxaphene was used as a prebloom spray, but in the late 1960's and early 1970's, growers applied other combinations:

Di-Syston and Furadan
Furadan and Cygon
Supracide and Cygon
Supracide and DySyston

These could be safely applied because bees were not working in the field at prebloom, and beneficial insects had not entered the fields.

Combinations of Dylox and Systox were applied to alfalfa seed crops to control pea aphids and Lygus bugs. Applications were made at night when pollinators were out of the field, and sometimes three or four applications per year were necessary. Lygus bugs were also a problem in red clover seed fields and often reduced the seed set by 20 percent.

In the 1970's, an IPM program was developed for alfalfa seed. Field scouts monitored plantings for insect pests and beneficials (such as the ratio of Lygus bugs and big eyed bugs) to determine whether spraying was necessary. Weed control, part of this *Lygus* management program, was practiced to remove dog fennel bordering the fields. Lacewings, pirate bugs, and damsel flies were also important insect predators. Pirimor, an extremely effective aphicide used in the 1970's, would kill aphids, but did not harm bees or insect predators. Though Pirimor was relatively nontoxic to bees, predators, and even fish, the EPA canceled its registration. However, in 1993, an emergency registration was granted for its use on alfalfa seed.

The twospotted spider mite had been a serious alfalfa seed pest. In the 1950's, Kelthane was applied with good success, but pest resistance grew and limited its utility. Galecron—hailed by many as the best miticide ever developed for control of the twospotted mite—was used extensively until the EPA canceled its registration. Since then, Comite has been used extensively but with limited utility.

The spotted alfalfa aphid became a major pest in alfalfa seed in the 1970's. Thiodan was the only chemical found to control this insect and not harm bees.

Table 11. Pesticide Use Comparisons for Oregon Clover and Vetch Seed Crops, 1981, 1987, 1992.

Herbicides	1981	1987	1992
2,4-DB	—	790	—
Benefin	—	900	1,200
Dinoseb	—	200	—
Diquat	—	3,900	—
Diuron	—	15,000	12,000
EPTC	2,000	3,700	43,000
Glyphosate	—	—	3,330
MCPA	2,000	1,400	400
Paraquat	—	—	9,800
Pronamide	10,000	6,400	2,600
Trifluralin	—	560	—
Insecticides	**1981**	**1987**	**1992**
Chlorpyrifos	—	550	3,700
Demeton	—	2,600	—
Dicofol	—	100	—
Malathion	—	3,800	—
Metaldehyde	—	7,000	—
Methoxychlor	6,000	7,100	2,380
Oxydemeton-methyl	—	2,800	2,500
Propargite	—	490	—

1980's

Buctril, and 2,4-DB were fairly standard broadleaf herbicides in alfalfa seed production throughout the 1970's and 1980's. Eptam and Balan were used as preplant soil herbicides during the same time period. It wasn't until Sonalan was registered in the 1990's that good, consistent control of nightshade was obtained. Pursuit, also registered in the 1990's, was used for control of grasses and broadleaf weeds. Pursuit, however, had a 2-year restriction for planting certain crops in rotation. Growers using Pursuit could not rotate out of alfalfa into crops such as corn or small grains the same year Pursuit was applied.

At the end of the 1980's, the registration of alfalfa seed as a nonfood crop expanded pesticide choices. Capture, a pyrethroid, became a mainstay of the industry for control of *Lygus*, replacing the old standard, Metasystox-R. It was applied near the time of bloom and would last the remainder of the season, controlling many insects, but not spider mites. The best protection against insect reinfestation is a clean field. Once pests are reduced, the beneficials help control recurrent outbreaks. Occasionally, growers would apply Dibrom or Phosdrin late in the season if Lygus bugs appeared. Some years, no additional sprays were necessary. Some resistance to Capture was noted in Washington state, but a new chemical, Karate, was registered in 1993. It was hoped that by alternating the pesticides applied, resistance could be forestalled or averted.

Table 12. Pesticide Use Comparisons for Oregon Alfalfa Seed Crop, 1981, 1987, 1992.

Desiccants	1981	1987	1992
Diquat	500	4,700	3,600
Dinoseb	15,200	410	canceled
Paraquat	500	—	380
Herbicides	**1981**	**1987**	**1992**
2,4-DB	—	1,500	580
Benefin	—	780	1,000
Bromoxynil	—	—	3,080
Chlorpropham	—	2,700	—
EPTC	—	1,100	340
Glyphosate	20,000	—	—
Hexazinone	—	830	—
Imazethapyr	—	—	70
Metolachlor	—	—	2,300
Metribuzin	—	650	5,400
Pendimethalin	—	—	10,800
Pronamide	—	430	—
Sethoxydim	—	8	140
Simazine	—	1,700	—
Sonalan	—	—	220
Trifluralin	—	490	770
Insecticides	**1981**	**1987**	**1992**
Bifenthrin	—	—	550
Carbofuran	400	5,300	520
Chlorpyrifos	—	950	380
Demeton	5,300	6,000	—
Dimethoate	400	2,700	380
Disulfoton	—	650	—
Endosulfan	1,000	2,600	—
Fluvalinate	—	3	—
Methidathion	200	640	380
Mevinphos	—	1,300	1,440
Naled	3,900	2,700	6,800
Oxydemeton-methyl	5,300	2,500	6,800
Propargite	2,900	5,400	3,600
Toxaphene	1,100	canceled	—
Trichlorfon	17,800	1,100	—
Vertebrate poisons	**1981**	**1987**	**1992**
Strychnine	—	22	—

Some diseases and nematodes were found in alfalfa seed crops, but they normally were not troublesome. White mold, however, appeared for the first time in large areas in 1992, and only time will tell whether this pest becomes a new threat in alfalfa grown for seed.

In the past few years, more alfalfa seed growers have built special harvesting equipment for cutting, drying, and combining. Many growers are moving in this direction because of the expense of defoliants; however, fields that are cut can also be blown away, as happened to luckless farmers in Lovelock, Nevada in 1992 when a strong wind removed the crop before harvest equipment did.

The 1981 statewide survey included some legume seed crops. Estimates from the 1981 survey, the subsequent 1987 survey, and the current survey are listed in Tables 11 and 12.

Alfalfa Seed Crop

Pest Control Practices

After a seedbed is prepared in the spring, Balan or Eptam is incorporated preplant. Eptam can cause more crop injury and will not last as long as Balan; however, it does provide some control of nightshade. If broadleaf weeds appear after the crop is planted, Butyrac is applied; if grasses appear, Poast is applied. When barnyardgrass or nightshade persist, Pursuit is used. In general, depending on the weed species that escapes control, these chemicals are applied the first year:

- Butyrac
- Poast
- Fusilade
- Buctril
- Pursuit

Prowl may be applied before bloom to remove dodder and grasses in established alfalfa.

When the crop is close to bloom, Capture is applied, and if a late cleanup spray is needed, Phosdrin or Dibrom are applied. Dodder is controlled with gramoxone spot spray. Comite is applied if mites are present in high numbers.

At the end of the first year of production, the crop is defoliated with Diquat.

Sonalan is applied to established plantings for nightshade control. Treflan, Eptam, and some diuron may also be applied to control grasses. Dual is rarely applied because nutsedge is rarely a problem; however, growers apply Pursuit or Butyrac if nightshade continues to be a problem. Two-thirds of the fields have dodder, and Prowl is applied to prebloom crops to control this parasitic weed. Capture is also applied prebloom, and late in the season Metasystox-R or Dibrom may be applied as a cleanup.

Crops are defoliated with Diquat and harvested. Total production lasts for 3-4 years, although some fields have been in production for as long as 30 years. Alfalfa is generally rotated into potatoes.

The 1992 pesticide use estimates for alfalfa seed crops are found in Table 13.

Red & Crimson Clover

Pest Control Practices

Crimson clover is an annual crop; red clover is a perennial. Red clover has a 2-3 year stand lifetime, depending on the level of clover root curculio, an insect for which there are no registered pesticide products. After growers prepare a seedbed, they incorporate Eptam and plant red clover in the spring. Some Balan DF is also used. Growers apply a combination of MCPA and Kerb 50W on crimson clover after two trifoliate leaves appear.

In the spring, farmers apply Metasystox-R or Lorsban to kill red clover and pea aphids. Crimson clover is not treated. A small amount of desiccant is applied to red clover. Crimson clover is harvested in early July, and red clover is harvested at the end of August.

Three noxious weeds on the certified seed list that must be controlled are buckhorn plantain, dock, and dodder. Between October and December of the second crop year of red clover, diuron and paraquat are applied to control broadleaf weeds. If grasses are a problem, Kerb and paraquat are applied. The clover must be dormant before paraquat can be applied safely. Some growers apply Kerb or diuron without paraquat. MCPA was formerly applied in the spring but is not used now because it is no longer registered for use on red clover. The 1992 pesticide use estimates for clover seed crops are found in Table 14.

Table 13. **Pesticides Use Estimates for Oregon Alfalfa Seed Crop, 1992. 11,000 acres.**

Common Name	Trade Name	Formulated Rate of Application	Normal Method of Application	Acres Treated	Pounds Applied a.i.
EARLY SPRING - preplant					
>>>>>>>Weeds: broadleaf weeds					
Benefin	Balan DF	1.5 - 3.0 lb/acre	incorporate	770 (10%)	1,000
EPTC	Eptam 7E	2.5 pt/acre	incorporate	150 (2%)	340
EARLY SPRING - established plantings					
>>>>>>>Weeds: annual grasses					
Trifluralin	Treflan 4EC	2.0 qt/acre	incorporate	380 (5%)	770
>>>>>>>Weeds: nightshade, broadleaf weeds					
Ethalfluralin	Sonalan	1.0 - 2.0 pt/acre	incorporate	380 (5%)	220
Metribuzin	Sencor	1.0 pt/acre	broadcast	5,400 (70%)	2,700
+ Pendimethalin	Prowl	2.0 pt/acre	broadcast	5,400 (70%)	5,400
>>>>>>> Weeds: nutsedge					
Metolachlor	Dual 8E	1.0 - 2.0 pt/acre	incorporate	1,500 (20%)	2,300
SPRING - new plantings					
>>>>>>>Weeds: broadleaf weeds					
2,4-DB	Butyrac	0.5 - 1.0 pt/acre	foliar	770 (10%)	290
Bromoxynil	Buctril	2.0 pt/acre	foliar	770 (10%)	380
>>>>>>>Weeds: grasses					
Sethoxydim	Poast	1.5 - 2.5 pt/acre	foliar	380 (5%)	140
>>>>>>>Weeds: nutsedge, watergrass					
Imazethapyr	Pursuit	4.0 fl oz/acre	broadcast	770 (10%)	50
SPRING - established plantings					
>>>>>>>Weeds: nightshade, dodder					
2,4-DB	Butyrac	0.5 - 1.0 pt/acre	foliar	770 (10%)	290
Bromoxynil	Buctril	2.0 pt/acre	foliar	5,400 (70%)	2,700
Imazethapyr	Pursuit	4.0 fl oz/acre	broadcast	380 (5%)	20
Metribuzin	Sencor	1.0 pt/acre	broadcast	5,400 (70%)	2,700
+ Pendimethalin	Prowl	2.0 pt/acre	broadcast	5,400 (70%)	5,400
PREBLOOM					
>>>>>>>Insects: *Lygus*, aphids					
Bifenthrin	Capture	0.06 - 0.1 lb a.i./acre	foliar	6,900 (90%)	550
Chlorpyrifos	Lorsban 4E	1.0 qt/acre	foliar	380 (5%)	380
Methidathion	Supracide 2E	2.0 qt/acre	foliar	380 (5%)	380
+ dimethoate	Cygon 400	1.0 pt/acre	foliar	380 (5%)	190
Carbofuran	Furadan 4F	1.0 qt/acre	foliar	380 (5%)	380
+ dimethoate	Cygon 400	1.0 pt/acre	foliar	380 (5%)	190

Table 13. Continued.

Common Name	Trade Name	Formulated Rate of Application	Normal Method of Application	Acres Treated	Pounds Applied a.i.
POST BLOOM					
>>>>>>>Insects: *Lygus*					
Naled	Dibrom 8	0.5 pt/acre	foliar	6,900 (90%)	3,400
Mevinphos	Phosdrin 4EC	0.5 - 1.0 pt/acre	foliar	1,900 (25%)	720
Oxydemeton-methyl	Metasystox-R	2.0 pt/acre	foliar	6,900 (90%)	3,400
>>>>>>>Insects: twospotted spider mites					
Propargite	Comite	2.5 pt/acre	foliar	3,800 (50%)	3,600
>>>>>>>Insects: cutworms					
Chlorpyrifos	Lorsban 4E	1.0 - 2.0 qt/acre	foliar	380 (5%)	140
>>>>>>>Weeds: dodder					
Paraquat	Gramoxone	0.5 pt/acre	spot spray	770 (10%)	380
LATE SPRING					
>>>>>>>Insects: *Lygus*, general cleanup					
Naled	Dibrom 8	0.5 pt/acre	foliar	6,900 (90%)	3,400
Mevinphos	Phosdrin 4EC	0.5 - 1.0 pt/acre	foliar	1,900 (25%)	720
Oxydemeton-methyl	Metasystox-R	2.0 pt/acre	foliar	6,900 (90%)	3,400
SUMMER					
>>>>>>>Weeds: defoliant					
Diquat	Diquat	1.0 - 1.5 pt/acre	foliar	5,700 (75%)	3,600

Table 14. **Pesticides Use Estimates for Oregon Clover and Vetch Seed Crops, 1991-1992. 18,750 acres red clover; 10,830 acres crimson clover; 4,420 acres of white, ladino, & arrowleaf clover; 8,000 acres vetch.**

Common Name	Trade Name	Formulated Rate of Application	Normal Method of Application	Acres Treated	Pounds Applied a.i.
FALL - New plantings, preemergence					
>>>>>>>Weeds: summer and winter annual weeds					
Red Clover					
EPTC	Eptam 6E	2.5 - 3.5 pt/acre	soil, incorp.	9,200 (40%)	21,000
Benefin	Balan DF	2.0 - 2.5 lb/acre	soil, incorp.	460 (2%)	550
Crimson Clover					
Pronamide	Kerb 50W	1.5 - 2.0 lb/acre	soil	10,000 (93%)	8,700
MCPA		4.0 lb a.i./acre	foliar	9,400 (87%)	1,200
FALL - Established plantings					
Red Clover					
>>>>>>>Weeds: buckhorn plantain, dock, dodder					
Glyphosate	Roundup	1.5 - 2.0 qt/acre	foliar	2,300 (10%)	3,500
Paraquat	Gramoxone	1.5 qt/acre	foliar	6,500 (30%)	9,900
>>>>>>>Weeds: winter annual weeds					
Diuron	Diuron 4L	1.0 - 1.25 qt/acre	soil	21,00 (90%)	26,000
Pronamide	Kerb 50W	1.5 - 2.0 lb/acre	soil	21,000 (90%)	10,000
Vetch					
>>>>>>>Weeds: winter annual weeds					
Diuron	Diuron 4L	1.0 - 1.25 qt/acre	soil	3,100 (41%)	3,800
Pronamide	Kerb 50W	1.5 - 2.0 lb/acre	soil	1,500 (20%)	1,500
SPRING					
Red Clover					
>>>>>>>Weeds: broadleaf weeds					
MCPA		0.5 pt/acre	foliar	1,200 (5%)	430
>>>>>>>Insects: pea aphid, clover aphid					
Chlorpyrifos	Lorsban 4E	1.5 pt/acre	foliar	12,000 (50%)	8,600
Oxydemeton-methyl	Metasystox-R	1.0 qt/acre	foliar	12,000 (50%)	5,800
Crimson Clover					
Chlorpyrifos	Lorsban 4E	1.5 pt/acre	foliar	1,600 (15%)	1,200
Oxydemeton-methyl	Metasystox-R	1.0 qt/acre	foliar	1,600 (15%)	780
Vetch					
>>>>>>>Insects: clover aphid, pea aphid					
Methoxychlor	Methoychlor 2E	2.0 qt/acre	foliar	2,300 (30%)	2,300

Sugar Beet Seed Crop

Production

In the late 19th century when sugar beets were first established in the United States, the sugar beet industry imported seed from European companies. This continued until 1914 when international commerce was interrupted by the war in Europe, and seed shipments declined, although some seed was still imported through Asia. As a result of the seed shortage, the United States production increased to about 5 million lb each year from 1916 to 1920.

After the war, European production resumed, and seed production in the United States declined rapidly. However, the purity and quality of European beet seed declined. Sometimes mangel seed was purposely substituted for beet seed, or the beet seed was impure because it was fertilized by off sources of pollen (such as Swiss chard). In order to maintain a genetically pure variety, growers had to isolate the seed crop from other pollinating sources. In addition, the seed had to be of high quality for uniform germination.

Until 1926, seeds were produced by transplanting crowns or roots into a field in the spring. However, growers discovered that late planted seed that overwintered in the ground would produce seed. Sugar beet is a biennial plant. In its first year, it sinks a root and stores energy to be used for seed production the following year. Normally, the root is harvested the first year for sugar. But if the plant is permitted to grow a second year, it sends up a tall stalk that bears seed. Under the European method of seed production, the roots were pulled from the ground in fall of the first year, stored through the winter, and replanted the following spring. Seed then grew atop a thick, woody stalk. To harvest the seed, workers hacked off the stalks with heavy knives. Under the American system, seed was planted in late summer or fall; the following spring, the plants sent up seed stalks. Winter frosts stop the growth of the immature beets just as effectively as if they had been pulled up and stored during the winter. In addition, the seed stalk was slender and could be cut down with a mechanical mower, eliminating the need for manual labor. At first, much of this seed was grown in Arizona, but since the winter temperatures were not sufficiently low to induce bolting on all varieties, new seed areas were sought. Temperatures had to be cold enough to vernalize the plant, but not so severe as to kill the plant. Day length was also important because it affected the growth of the seed crop. Growers noted that the Willamette and the Rogue valleys in Oregon were excellent regions to grow seed because of the long, relatively mild winters and

Figure 12. Annual Acres of Oregon Sugar Beet Seed Harvested, 1937-1992.

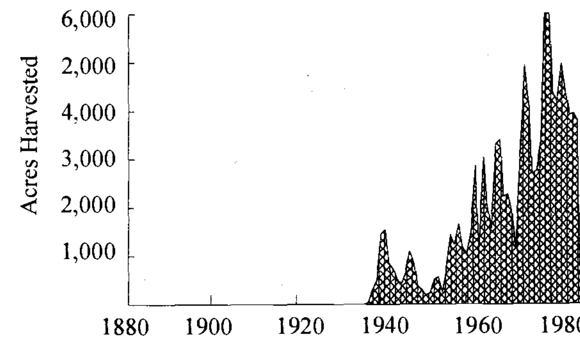


Figure 13. Annual Production of Oregon Sugar Beet Seed Harvested, 1937-1992.

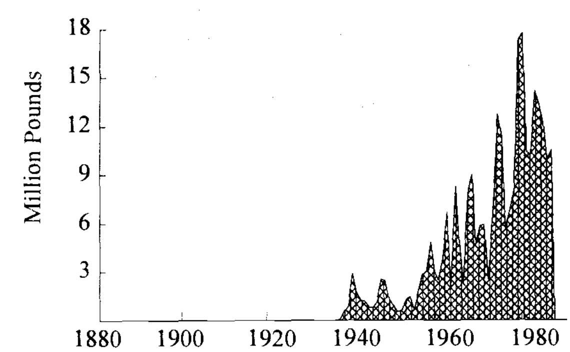
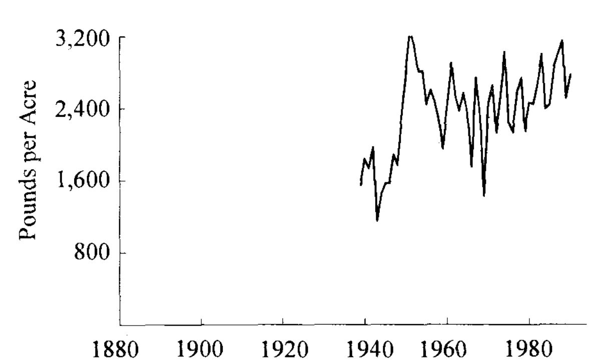


Figure 14. Annual Average Yield of Oregon Sugar Beet Seed Harvested, 1937-1992.



USDA Agricultural Statistics, 1937-1990.

temperatures favorable to seed development. In 1936, seed was produced in Oregon on experimental plots near Central Point and in the Willamette Valley. The success of the plantings led to large-scale seed production in following years.

War broke out in Europe in 1939, and because European seed was unavailable, United States beet seed acreage was expanded to meet domestic needs. By 1941, the United States was self-sufficient in sugar beet seed production.

The 1940's brought major changes in planting, growing, and harvesting cultural practices, even though the war had limited the availability of equipment and replacement parts. Demand for seed dropped during the war, and seed acreage decreased.

During the 1950's, most of the problems associated with planting were resolved. Because beet seed was multigerm (clustered seeds), it had to be thinned by hand or machine. But during the 1940's and 1950's, machinery improved and could break apart the seed.

The development of male-sterile lines in the mid-1950's led to the immediate production of large quantities of multigerm hybrid seed. The male-sterile plants would not pollinate their own flowers so another variety could be used, and any seed produced would be hybrid. These hybrid seeds were superior to the open pollinated varieties and quickly replaced them.

The 1960's brought advances in seed handling, such as the use of bins instead of bags. In addition, the discovery of the monogerm seed plant in 1948 led to the development of the single germ seed; by 1960, half of the seed crop consisted of monogerm varieties. By the end of the decade, all commercial seeds were monogerm hybrid varieties.

Seed production declined in all areas except Oregon, and by the end of the 1970's, Oregon emerged as the sole sugar beet seed growing area in the United States. Today, Oregon supplies sugar beet seed for the world. If demand for seed increases, the Willamette Valley has ample land on which sugar beet seed can be raised.

Changes in Oregon acreage, production, and yield are shown in Figures 12, 13, and 14.

Historical Pesticide Use in Sugar Beet Seed Crop

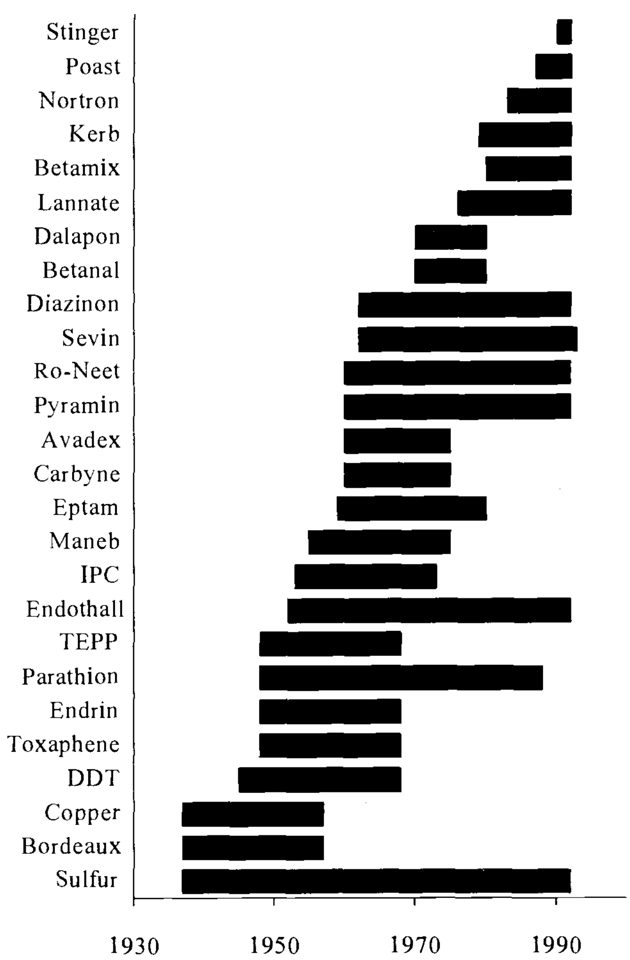
Pesticides were not used during the first years of Oregon sugar beet seed production, but not for a lack of pests. Figure 15 shows the pesticides most commonly used from about 1937, when Oregon seed production began, to 1992. From the outset, curly top virus, carried by the beet leafhopper, was the most serious pest problem on sugar beets grown for sugar, but it was never a problem for the seed crop. Curly top caused severe crop losses and resulted in factory closures from the turn of the century onward. Virus resistance was discovered in certain beets, and, over many years, this resistance was bred into the commercial varieties. As a result, curly top is no longer a serious disease on sugar beets grown for sugar.

Growers began to treat cercospora leaf spot and ramularia leaf spot with sulfur dust, probably in the late 1930's. While cercospora was a serious disease on the sugar beet for sugar crop, it was never a problem for the seed crop. When downy mildew was a problem, growers applied Bordeaux or other copper dusts, although control was often negligible.

Several insects are, from time to time, pests in sugar beet seed fields:

- *Lygus*
- twospotted spider mites
- black bean aphids
- variegated cutworms

Figure 15. Prominent Pesticides Used on Sugar Beet Seed, 1937-1992.



Some insects that caused material damage during the early years were not treated, but shortly after World War II, newly available insecticides controlled these insects. Endrin and toxaphene were effective on cutworms and replaced arsenic poison baits (such as those made with Paris green). A 5 percent DDT dust replaced the combination of sulfur and pyrethrum for *Lygus* control in 1945.

Because of the importance of sugar, the USDA began a breeding program to produce a good domestic variety of sugar beet with some resistance to curly top, a serious disease for which there was no chemical control. In 1930, the USDA released USI, a new variety that showed some resistance to curly top. This marked the beginning of the sugar beet seed industry in the United States.

The beet leafhopper carries the curly top virus, which is the most destructive sugar beet disease. A large-scale program to destroy this virulent pest included the removal of weeds that shelter the curly top virus over the winter and the destruction of the leaf hopper breeding grounds. DDT and parathion were used to combat this pest until the late 1960's. TEPP and parathion, available shortly after World War II, were used to control all aphid pests until about 1970.

After the war, seeds were planted in late summer. The crop was cultivated after beets emerged, and cultivations continued through the fall and spring as soil conditions permitted. Hand hoeing was also required. Until 1953, when IPC and endothall were commercially used in sugar beets, cultivation remained the major method of weed control. Diesel oil was sometimes used as a preemerge spray, and there was some use of common salt as well. IPC, later known as Chem-Hoe, was effective in controlling many seedling grasses. Endothall, later known as Herbicide 273, was used to control seedling grasses and broadleaf weeds during the winter. Typically, growers applied 4 lb of IPC and 2 lb of endothall (separately or together) in late summer or in the fall after the beets had several leaves. Generally, growers tried to cultivate two or three times in the fall and two or three times in the spring until the plants were large enough to shade out the weeds.

By the late 1950's, Eptam was available and was incorporated as a preplant treatment (in addition to other treatments). Carbyne, Avadex, and Pyramin soon were registered. Carbyne and Avadex (preplant treatments) controlled wild oats, and Pyramin, applied after planting, but before emergence, controlled many broadleaf weeds.

Major herbicides in use in the 1960's were these:

- Eptam
- Ro-Neet
- IPC
- Endothall

Eptam and Ro-Neet were applied as preplant treatments at the rate of 3 to 4 lb of active ingredient per acre. Both herbicides provided good control of grasses and most broadleaf plants during the fall growing season. IPC applied at 6 lb active ingredient per acre was especially effective on chickweed. Endothall was applied as a contact spray during the winter months when the beet crop was dormant. Fields were cultivated two or three times and hoed by hand in the fall to aid weed control. IPC was applied if grasses were a problem, and, later, an application of endothall was made to control late germinating weeds. In the spring, growers tried to cultivate two or three times before mid-May when the seed stalks interfered. Additional hoeing was sometimes necessary. By the end of the decade, the trend in weed control favored combinations of herbicides rather than a single treatment. Ro-Neet worked well against grasses and certain broadleaf weeds and was generally used in combination with Pyramin or Betanal. Treflan was added to the herbicide inventory at the end of the decade.

At first, insects were not considered a major problem. But when populations of *Lygus*—the most harmful insect to seed beets—demanded control, growers applied DDT aerially. Other insects that occasionally infested fields were these:

- green peach aphid
- spider mite
- leaf cutworm
- spittlebug

The most prevalent sugar beet seed diseases in the 1960's were ramularia leaf spot and phoma leaf spot. These diseases surfaced in the late fall, but as the beet leaves withered away during the winter, the infection was reduced. In the more susceptible seed varieties, leaf spot appeared again in the early summer. In some instances, fields were nearly defoliated by harvest time; no control measures were effective. Western yellows appeared occasionally but was not considered damaging to the crop. Other diseases of minor importance were downy mildew and mosaic. Damping-off was controlled, to some degree, by timely watering. *Pythium* is the major cause of pre- and post-emergence damping-off of young seedlings. Damping-off organisms attack germinating seeds, causing them to darken and wilt.

Beginning in about 1970, growers used dalapon to control annual grasses. Betanal was applied for control of annual grasses and broadleaf weeds. Occasionally, Paraquat was used as a preplant herbicide to kill any germinating weeds. Later, when Betamix was registered, it was often used in place of Betanal.

In 1979, growers applied Kerb for grass control. Shortly afterward, Roundup was registered as a preemerge spray for seedling weeds. Nortron was registered in the early

1980's for control of seedling grasses in established sugar beet plantings. Poast, another grass herbicide, was registered by the mid-1980's. Last, Stinger was registered to control persistent perennials such as Canada thistle.

Table 15 lists the amount of pesticides applied to sugar beet seed crops in 1981, 1987, and 1992.

Table 15. Pesticide Use Comparisons for Oregon Sugar Beet Seed Crop, 1981, 1987, 1992.

Herbicides	1981	1987	1992
Chlorproham	—	440	—
Clopyralid	—	—	40
Cycloate	15,000	9,400	20,000
Desmedipham	—	110	910
Endothall	8,000	4,900	8,100
Ethofumesate	—	—	310
Phenmedipham	5,000	1,200	910
Pronamide	4,000	1,900	4,200
Pyrazon	—	—	6,800
Sethoxydim	—	30	110
Trifluralin	—	250	—

Insecticides	1981	1987	1992
Carbaryl	—	50	280
Chlorpyrifos	—	1,400	2,800
Diazinon	—	—	560
Fonofos	8,000	1,300	5,600
Malathion	—	20	—
Metaldehyde	—	—	340
Methomyl	—	—	140
Oxydemeton-methyl	—	140	2,800
Propargite	—	—	450

Fungicides	1981	1987	1992
Chlorothalonil	1,000	1,800	710
Mancozeb	—	—	470
Metalaxyl	—	—	110
Sulfur	46,000	48,000	46,000
Triadimefon	—	3,200	—

Typical Pest Control Year

Sugar beet planting begins in mid-August after the late July or early August beet seed harvest. To prepare fields, growers apply Ro-Neet and till it into the soil to control broadleaf weeds and grasses. Most growers add Dyfonate or Lorsban to control symphylans. After the seedbed is prepared, growers plant beet seed that is treated with Apron and captan to help control damping-off and root rots. Some growers apply Pyramin postplant.

The weed history of each field is important in determining what herbicides to apply. In September or October, after the beets have emerged, Betamix is applied for broadleaf weed control. Occasionally, Herbicide 273 is added for control of specific weeds like black mustard. However, if seedling grasses are a problem, Nortron is banded in the crop row. If pineapple weed, dog fennel, or Canada thistle are present in the field, growers also apply Stinger.

It is not uncommon for slugs or 12-spotted beetles to injure or destroy seedling beets. Metaldehyde baits are used for slug control. Carbaryl or diazinon control the beetle; Lorsban or diazinon may be applied for black bean aphid control. Downy mildew, an occasional disease problem, is treated with Ridomil MZ50 or Bravo 720.

Between December and February, fields are treated again with herbicides. Herbicide 273 is applied one of two ways. In the past, it was applied alone at 1 gallon per acre, but today most growers apply it with liquid nitrogen at reduced rates. The cost is the same, but the control is better. Growers apply Kerb for control of chickweed or grass; they also may apply Poast to control grasses.

When seed is cleaned at the plant, seed screenings are normally fed to livestock. However, seed screenings from Kerb-treated fields must be excluded from feed. Instead, screenings are used along with bark, chips, and other combustibles to fuel paper mill boilers.

In some instances, it is necessary to transplant sugar beets in the spring. This is done either to increase the current number of acres or to plant a new variety from a sugar beet nursery. In these cases, Nortron and Pyramin are applied to control weeds.

Growers apply sulfur in mid-May and again in mid-June for leaf spot or to prevent powdery mildew. Often Metasystox-R is included in the June spray for aphid or *Lygus* control. Sometimes the black bean aphid is a problem in June, and diazinon or Lorsban is applied.

The twospotted spider mite is an occasional pest in Willamette Valley beet seed and a perennial problem in beet seed grown near Central Point in the Rogue Valley. Comite is applied in July in the Willamette Valley, but a month earlier in the Rogue Valley.

When black cutworms are numerous and begin to eat the terminal buds, growers apply Lannate.

The 1992 pesticide use estimates for the Oregon sugar beet seed crop are found in Table 16.

Table 16. Pesticides Use Estimates for Oregon Sugar Beet Seed Crop, 1992. 5,464 acres.

Common Name	Trade Name	Formulated Rate of Application	Method of Application	Acres Treated	Pounds Used a.i.
SEED TREATMENT					
>>>>>>>Diseases: root rots, damping-off					
Metalaxyl	Apron	4.0 oz/100 lb seed	seed treatment		6
PREPLANT - August 15					
>>>>>>>Weeds: broadleaf weeds and grasses					
Cycloate	Ro-Neet 6E	3.0 qt/acre	broadcast, incorp.	4,500 (80%)	20,000
>>>>>>>Pests: Symphylans					
Chlorpyrifos	Lorsban 4E	2.0 qt/acre	broadcast, incorp.	560 (10%)	1,100
Fonofos	Dyfonate 4E	2.0 qt/acre	broadcast, incorp.	2,800 (50%)	5,600
PREMERGENCE					
>>>>>>>Weeds: broadleaf weeds					
Pyrazon	Pyramin DF	4.8 - 5.7 lb/acre	4"-6" band	5,600 (100%)	6,700
POST-EMERGENCE - September and October					
>>>>>>>Weeds: lambsquarter, mustard, nightshade					
Desmedipham + Phenmedipham	Betamix	2.0 - 6.0 pt/acre	broadcast	5,600 (100%)	1,820
>>>>>>>Weeds: black mustard					
Endothall	Herbicide 273	0.5 - 1.0 pt/acre	broadcast	280 (5%)	54
>>>>>>>Weeds: seedling grasses, annual ryegrass, chickweed					
Ethofumesate	Nortron ES	3.0 - 8.0 qt/acre	banded	280 (5%)	260
>>>>>>>Weeds: grasses, wild oat, volunteer grain, quackgrass					
Sethoxydim + oil	Poast	1.5 - 2.5 pt/acre	foliar	280 (5%)	110
>>>>>>>Weeds: pineapple weed, dog fennel					
Clopyralid	Stinger	0.25 - 0.5 pt/acre	foliar	280 (5%)	40
>>>>>>>Pests: slugs					
Metaldehyde	Metaldehyde 4 Bait	30 lb/acre	broadcast	280 (5%)	340
>>>>>>>Pests: 12-spotted beetle					
Diazinon	AG500	1.0 qt/acre	foliar	110 (2%)	110
Carbaryl	Sevin 4	1.0 qt/acre	foliar	280 (5%)	280
>>>>>>>Pests: black bean aphid					
Chlorpyrifos	Lorsban 4E	1.0 qt/acre	foliar	560 (10%)	560
Diazinon	AG500	1.0 qt/acre	foliar	170 (3%)	170
>>>>>>>Diseases: downy mildew					
Metalaxyl	Ridomil MZ50	1.5 - 2.0 lb/acre	foliar	560 (10%)	100
+ mancozeb				560 (10%)	470
Chlorothalonil	Bravo 720	2.5 pt/acre	foliar	560 (10%)	710
WINTER - December to February					
>>>>>>>Weeds: winter annuals					
Endothall + solution 32	Herbicide 273	2.0 - 3.0 qt/acre	foliar	4,200 (75%)	8,000
>>>>>>>Weeds: chickweed, annual grasses, volunteer grains					
Pronamide	Kerb 50W	2.0 lb/acre	soil	4,200 (75%)	4,200

Table 16. Continued.

Common Name	Trade Name	Formulated Rate of Application	Method of Application	Acres Treated	Pounds Used a.i.
EARLY SPRING - Transplants					
>>>>>>>Weeds: broadleaf weeds, grasses, redroot pigweed, volunteer grains					
Ethofumesate	Nortron ES	3.0 - 8.0 qt/acre	banded	50 (<1%)	45
>>>>>>>Weeds: broadleaf weeds					
Pyrazon	Pyramin DF	4.8 - 5.7 lb/acre	banded	50 (<1%)	60
SPRING - Mid-May					
>>>>>>>Diseases: leaf spot, powdery mildew					
Sulfur	Microthiol Special	5.0 lb/acre	foliar	5,600 (100%)	28,000
LATE SPRING - Mid-June					
>>>>>>>Diseases: leaf spot, powdery mildew					
Sulfur	Microthiol Special	5.0 lb/acre	foliar	3,600 (65%)	18,000
>>>>>>>Insects: aphids, *Lygus*		Oxydemeton methyl	Metasystox-R	2.0 pt/acre	foliar
5,600 (100%)	2,800				
Diazinon	AG500	1.0 qt/acre	foliar	280 (5%)	280
Chlorpyrifos	Lorsban 4E	1.0 qt/acre	foliar	1,100 (20%)	1,100
>>>>>>>Insects: cutworms and loopers					
Methomyl	Lannate	0.5 lb/acre	foliar	280 (5%)	140
SUMMER - July					
>>>>>>>Insects: twospotted spider mites					
Propargite	Comite	1.0 - 2.0 pt/acre	foliar	360 (6%)	450

Vegetable & Flower Seed Crops

Production

The vegetables we commonly eat are not native to North America. The colonists found a few of Central or South American origin—corn, pole beans, and pumpkins—being grown by the Indians, but all others, including the South American tomatoes and potatoes, were introduced from the Old World. As time passed, the best plant varieties were selected, and their seeds led to strains better adapted to colonial conditions. With such developments and the further opening up of the country, seedsmen (seed sellers) became more necessary. In the mid-18th century, the American seed industry came of age. At first, seed was exchanged largely on a farm-to-farm barter basis. But by the 1920's, industry leaders marketed clean seed from the farm, something not commonly done in the rest of the Union. Raising clean seed was also unique to Oregon. Seed processing by commercial plants followed, along with better warehousing and better marketing. Seed certification was employed, resulting in increased overall seed quality and verification of the authenticity of varieties.

While many flower, vegetable, herb, and field seed crops have been grown in Oregon, some are no longer in production. Flax seed was produced from the time of early settlement until shortly after World War II. Seed production was sporadic with a record seed yield of 37,000 tons in 1942. Fiber flax was used to make linen and, even though the nation's entire fiber flax production was confined to the Willamette Valley, flax seed was never an important Oregon crop.

Many vegetable seed crops are grown in Oregon. Recent crops include these:

- carrots
- onions
- radish
- coriander
- dill
- parsley
- edible chrysanthemum
- Chinese cabbage
- sweet corn
- mustard
- kale
- Brussels sprouts
- collards

Even more flower types are grown. These are some of the more common flowers:

- primroses
- alyssum
- chrysanthemum
- California poppies
- cerastium
- zinnia
- marigolds
- coreopsis

Seed is grown in the Willamette Valley, central Oregon, the Columbia basin, and Malheur County. Production in the central Oregon region has expanded rapidly in the last 15 years.

Isolation of one crop from another is important in seed production. To maintain a pure seed line, other growers must be a sufficient distance away to decrease the possibility of cross-pollination. Often, a distance of several miles between crops is necessary to maintain purity. Fields planted in seed crops are mapped, and cooperation among seed companies is usually sufficient to ensure isolation. The growing area in central Oregon cannot be further expanded because the possible production areas are filled. The entire world production of many flower and vegetable seeds is grown on a few acres.

Climate is important in seed production, and Oregon has a climate with little or no rainfall during the harvest period. The Willamette Valley has a mild winter and a dry summer, allowing high survival for overwintering crops and good harvest conditions. The central Oregon region has colder winters, but its high desert summers are not overly hot and allow the seed to fill and develop.

Pest Control Management Practices

Flower Seed Crop

Oregon growers apply few chemicals to flower seed crops because of limited pesticide registrations. Treflan is the most widely registered herbicide, but because it has a limited weed control spectrum, it is essential that the ground be relatively weed-seed-free when crops are planted. Therefore, crop rotation is the most important cultural practice for maintaining weed control. Flower growers prefer to plant seed in fields where crops such as potatoes, wheat, and corn have been grown. They prefer to avoid crops of the same plant family or crops known to harbor diseases. For example, curly top disease in sugar beets is caused by a virus carried by sugarbeet leafhoppers; this disease also is a threat to zinnias. Thus a grower would not plant zinnias in a field that previously produced sugar beets.

Water from rivers or canals is often contaminated with weed seeds. This source of contamination has become a problem in the Treasure Valley, where irrigation canal banks are no longer kept weed free. Screening out weed seed is difficult because of algae buildup, which quickly clogs screens. In previous years, xylene, acrolein, or salts of endothall were applied to canals to kill algae, but this is no longer done. Important weeds in the Treasure Valley area include the following:

- pigweed
- common mullein
- lambsquarter
- Canada thistle
- nightshade
- barnyardgrass
- cocklebur
- bindweed
- kochia
- wild carrots

Fields are often worked in the spring and remain fallow through the summer in preparation for fall planting. This allows growers more time to kill troublesome weeds. Normally, they apply Roundup or Gramoxone after seedbeds are prepared for planting. Treflan, and sometimes Eptam, are broadcast and cross disced in before flower seed is planted. After planting is completed and before the flower crop emerges, growers apply Roundup if more weeds have emerged. Because growers prefer to plant flower seed following grain or grass seed crops, they apply Poast or Fusilade to control volunteer grains and grasses.

Important weed problems in the Willamette Valley include the following:

- thistles
- mustards
- annual bluegrass
- chickweed
- knotweed

Napropamide is applied over the top of the seedling flowers in the fall, just after the first rain, and again in the winter.

Treatments with such chemicals as

- pendamethalin
- pronamide
- bentazon
- clopyralid
- oxyfluorfen

help control winter annual weeds. Often, the flower is dormant or is completely underground. A contact herbicide, like Gramoxone, is useful in the winter under these circumstances. Flowers are cultivated once in the fall (before the rains) and two or three times in the spring.

Diseases are a problem in perennial flowers. Anthracnose, powdery mildew, and pythium root rot are some of the most severe. To help control these and other diseases, these pesticides are applied:

- benomyl
- captan
- mancozeb
- chlorothalonil
- vinclozolin
- iprodione
- Fosetyl-Al

Pythium, septoria, and other root rots were severe in 1991 but not in 1992. Entire fields of larkspur, bachelor buttons, zinnias, and others have been lost because of disease. Less problematic diseases include the following:

- aster yellows
- leaf spot
- downy mildew
- *Botrytis*

Ridomil, Bayleton, and sulfur dust are applied for these diseases, and many flower seeds are treated with Apron.

Perennial insect pests on most flowers seed crops include:

- aphids
- *Lygus*
- mites
- white flies
- leafhoppers
- 12-spotted beetles
- thrips

Lygus and white flies were particularly severe in 1992. Diazinon is most often applied for the foliar insects. Thiodan and azinphos-methyl are also used. Neighboring crops affect insect populations in flowers, and unless these crops are treated, they provide host material for insects. In one instance, white flies moved into zinnias from sugar beets. Onions are an excellent host for thrips, and growers try not to plant petunias, a thrips' host, adjacent to an onion patch. Zinnias and asters cannot be planted next to alfalfa without incurring *Lygus* damage. Lorsban is used when symphylans are present. The sphinx moth is an annual pest on evening primroses and always must be controlled; Thiodan is effective when applied early. Seed screenings are returned to the fields and mulched.

Pesticide use comparisons for Oregon flower and vegetable seed crops for 1981, 1987, and 1992 are listed in Table 17. Table 18 shows 1992 pesticide use estimates for flower seed crops.

Vegetable Seed Crops

Brassica seed crops include these:

- cabbage
- radish
- mustard
- collard
- Brussels sprouts

These crops and others are grown in Washington, Oregon, and Idaho. There are about 300 acres of red radishes and 800 acres of daikon radishes. Over the last few years, daikon radish production has fluctuated between 400 and 1500 acres. Although there are about 800 to 1000 acres of cabbage seed crops in Oregon, only a small acreage of the other brassica seed crops are grown in Oregon.

Sprouting radishes are considered a food crop, and while some chemicals are registered for use on red radishes, fewer are registered for daikons. Daikons are planted in late March and red radishes by early April. Lorsban granular or Lorsban 4E is applied in the furrow to help control the cabbage maggot. Normally, a second maggot treatment is necessary, but because Lorsban can be applied one time only, diazinon granules are used for the second treatment. If a second cabbage maggot treatment is needed when bees are working in the field, no pesticide is applied and less seed is harvested. Other radish pests include the following:

- diamondback moths
- aphids
- *Lygus*
- sand beetles

If sand beetles do not appear early in the season, the plants can normally outgrow them. In the past, DiSyston was used, but it is no longer registered. Dyfonate is effective against sand beetles, but it causes plant damage.

Occasionally, downy mildew and white rust are problems and can be treated by application of Ridomil in the early spring. White rust is a serious disease on radish seed crops some years, but it was not a problem in 1992. Beet leaf hoppers spread the BLTVA mycoplasm, and crops have been lost because of this disease. Coriander is also susceptible to this mycoplasm. White mold is treated with Benlate in April at early bloom. *Alternaria* is treated in mid-May with one to three applications of Rovral or Bravo. Dithane was used in the past.

In the Treasure Valley, Eptam was used in the past, but it injured the plants. Therefore, Treflan is incorporated into the soil at planting, and Butyrac is applied later in the spring. Direct-seeded cabbage is planted the first of August and transplanted cabbages at the end of August. Treflan (and occasionally Dual) is incorporated into the seedbeds; Goal is applied just prior to transplanting young cabbage plants. In the fall, simazine is broadcast to control germinating winter annual weeds. In fields previously planted in cereal, volunteer grains are spot-treated with Fusilade. Goal may be applied in mid-winter when plants are dormant.

Most years, wet fields prevent growers from cultivating until spring; therefore, chemical control in the winter is necessary. The worst weed is bedstraw, but others include the following:

- wild radish
- wild turnips
- wild mustards
- vetch

Most of these weeds produce seed that is nearly impossible to remove from the crop seed. Prickly lettuce, shepherdspurse, and groundsel interfere with harvest but are not seed contaminant problems. If weeds persist, some growers apply a light treatment of simazine during the winter.

Root maggots are an annual problem. One application of Lorsban is normally sufficient to control them, although sometimes two treatments are needed. Maggots can move into the stem of the plant in the fall. To prevent this, granular Lorsban is incorporated in the furrow with a chain drag when the crop is direct seeded. Otherwise, Lorsban 4L is sprayed and watered in.

Dyfonate is used to control symphylans. Aphids, which transmit viruses, are controlled with MSR or azinphos-methyl. All fields are monitored for aphid infestation. Most do have infestations of aphids, and the cabbage aphid is the most difficult to control. Cutworms and loopers are occasional problems, and Lorsban is used to control them. The cabbage seedpod weevil is a pest during the flowering period. Parathion was used in the past, after bloom, because it could penetrate the pod and kill the weevil; today, Spur is used. The cabbage seedpod weevil is becoming increasingly difficult to control, especially in the hybrid varieties, and losses in hybrids are much more costly than in open pollinated varieties because the seed is more valuable. Flea beetles are normally a problem only in the spring; Thiodan or Sevin are applied occasionally for control. Some plot work with Capture has been undertaken.

After crops are planted, slugs must be treated. Generally, 10-20 lb of bait per acre is sufficient when bait is scattered along the perimeter of the field in a 20-foot band.

Carrot seed crops are grown in Oregon and Idaho. About 1,500 acres are grown in central Oregon and 500-600 acres in the Treasure Valley. Growers most commonly rotate into carrots from grain crops. Seed is planted at the end of August; stecklings (carrot roots) are planted in the spring.

Most seed is treated with a hot water bath and thiram or Apron. Apron is used to control *Alternaria.* Seedbeds are prepared, and Treflan is incorporated prior to planting. Linuron is applied in late summer or early fall if a flush of summer annual weeds appear. Common summer annual weeds are nightshade, lambsquarter, and pigweed. The soil is cultivated one or two times in the fall and up to four times in the spring. More cultivation is done in the Treasure Valley than in central Oregon. Fusilade is broadcast or applied as a spot treatment on earlier plantings

Table 17. Pesticide Use Comparisons for Oregon Flower and Vegetable Seed Crops, 1981, 1987, 1992.

Fungicides	1981	1987	1992
Benomyl			840
Captan			600
Chlorothalonil	400		4,600
Copper			4,500
DCNA	1,800		
Fosetyl-Al	——	——	5
Iprodione			880
Mancozeb			1,100
Metalaxyl		250	340
Sulfur	1,300	2,300	500
Thiram			10
Triadimefon			100
Vinclozolin			160

Herbicides	1981	1987	1992
2,4-DB			90
Alachlor			500
Bensulide			1,200
Bentazon			20
Bromoxynil	400		100
Chloroxuron	2,600		
Clopyralid			20
Cypermethrin			140
DCPA			230
Dinoseb		1,500	
Endothall		80	
EPTC			700
Fluazifop-butyl			210
Glyphosate			2,300
Linuron	——	1,200	2,600
Metolachlor	——	——	970
Napropamide			1,200
Oxyfluorfen			280
Paraquat	400		800
Pendamethalin			250
Pronamide	400	25	30
Sethoxydim			200
Simazine			280
Trifluralin		1,200	4,200

Insecticides	1981	1987	1992
Acephate			700
Azinphos-methyl			280
Bacillus thuringiensis			50
Bifenthrin			170
Carbaryl			900
Chlorpyrifos		170	6,000
Cypermethrin	——		210
Diazinon	——	70	1,600
Endosulfan	——	60	190
Esfenvalerate	——	——	150
Fenvalerate	——	6	——
Fluvalinate		80	90
Fonofos	200		620
Lambda-cyhalothrin			12
Malathion		45	260
Metaldehyde	——	750	180
Methamidophos		800	
Methomyl			150
Methyl parathion			110
Mevinphos			160
Oxydemeton-methyl		340	250
Parathion		18	
Permethrin			110
Propargite			100
Terbufos			300
Trichlorfon		300	

when barnyardgrass, millet, and other grasses are present. Growers who burn wheat stubble have fewer weed problems and generally do not apply linuron. Weeds that can contaminate the harvest seed include

- Canada thistle
- bindweed
- mallow
- Russian thistle

These weeds must be hand-hoed. Between cultivations at the end of April, stands are blocked by hand. Blocking, or thinning, increases yield, decreases lodging, facilitates harvest, and lowers the disease potential. Winter annual weeds are pulled by hand, but flushes of summer annual weeds are sprayed with Lorox or Fusilade. Spray nozzles are held close to the ground to better target the herbicide application.

Occasionally, variegated cutworms, thrips, and aphids are pests in the early spring. Lorsban 4E (or sometimes Lannate) is applied to control them. In central Oregon, growers commonly apply Lorsban in the fall to control cutworms. *Lygus*, the most serious insect pest in carrots, is also found in coriander, parsley, and parsnip seed crops. Capture is applied about the first of July and again during the second week of August for *Lygus* control. Capture contains *Lygus* infestations for 2 to 4 weeks. When necessary, growers tolerate *Lygus* until bloom has passed. Fields are monitored for *Lygus* and its predators, the big eyed bug and damsel bug. Other *Lygus* treatments include

- Lorsban
- Spur
- Orthene (Washington only)
- Phosdrin

malathion
Asana XL

Monitor was used in the past, but it tended to repel bees. Dylox is toxic to bees and is not used. Spur disorients the worker bees and is not a good choice for treatment. *Lygus* can do a tremendous amount of damage during the last few weeks before harvest; therefore, Lorsban is applied after bloom. Mites are pests that can be aggravated when peppermint or alfalfa are harvested, causing the mite population to migrate. Capture controls mites.

White mold, *Alternaria*, and xanthomonas bacterial blight are carrot seed crop diseases. *Alternaria* can be carried in the harvested seed. Some growers apply Kocide 606 in the spring to protect against *Alternaria*. In the Treasure Valley, carrots generally are treated mid-May, the end of May, and mid-June with Bravo or Rovral plus Kocide 606. Kocide is added for control of *Xanthomonas*. Leaf blight and black crown rots also affect carrots.

Onion seed crops are grown in the Treasure Valley, central Oregon, and north of Salem in the Willamette Valley. About 300 acres are grown in central Oregon, less than 100 in the Willamette Valley, and about 800 in the Treasure Valley.

Onions are planted in late summer. A planting bed is prepared, watered, and cultivated after the emergence of summer annual weeds. In the Treasure Valley, Prefar 4E is applied prior to planting; Dacthal is used in central Oregon. In central Oregon and the Willamette Valley, overhead irrigation moves Dacthal into the seedling zone. Treasure Valley growers irrigate primarily with ditches. Before the onions emerge, the summer annual weeds are often sprayed with Roundup. Lorsban 15G or granular diazinon is applied in the furrow at planting.

The soil is cultivated and hoed regularly. In the fall, Goal and Buctril are applied between cultivations. Hand weeding is done periodically. During the winter or spring, Prowl, Poast, or Fusilade is sometimes applied.

Thrips are a serious insect problem on onion crops; growers alternate pyrethroids with these insecticides:

Ammo
Cymbush
Pounce
Lannate
Karate
Phosdrin
Penncap-M
malathion

Often, four to five applications are necessary in the Treasure Valley. Parathion had been the standard treatment in previous years.

Botrytis is the foremost disease on the onion seed crop and was quite extensive in 1992. Other serious diseases that occasionally are a problem include these:

Downy mildew
purple blotch
fusarium
pink root

Chemicals that are used to control these diseases are:

Ridomil
Bravo
Dithane
sulfur
Kocide
Rovral

Depending on rainfall and humidity, in mid-March, Treasure Valley growers make three to five sequential applications using one or more of these chemicals. An insecticide is added to each tank mixture, depending on the thrips population. If a hailstorm damages the crop, either Bravo or Rovral is applied. After bloom, Bravo, or sometimes Rovral, is applied for control of botrytis. If thrips are still a problem, growers apply any one of the insecticides used earlier.

Sweet corn seed crops are grown in Washington, Oregon, and Idaho. About 10,000 acres were grown in the Treasure Valley in 1992, with the bulk of these planted on the Idaho side of the border.

Corn seed is normally treated with thiram, Apron, or captan. Prepared seedbeds are treated with Lasso (or less often Dual), broadcast prior to planting. Sometimes Bladex is also used. After crops are planted but before the corn emerges, many growers cultivate by dragging the field. Normally fields are cultivated three to four times before the corn is high enough to prohibit tractor cultivation. If millet (a major weed problem) or other weeds persist, atrazine plus oil is banded in the corn row.

When crops are planted, seed corn maggots and wireworms are controlled by an in-furrow application of granular Counter or Lorsban. Overlapping generations of corn earworms are difficult to control, and infestation pressure is variety dependent. Tight husks and well filled ears are less susceptible to the earworm. Sevin, Asana, Ambush, and Dipel are all used and applied by ground equipment two or three times to control the maggot. Mites are treated with Comite plus sulfur and an attractant. Many growers treat the corn two or more times.

Diseases are also variety dependent. Shrunken kernel sweet varieties are susceptible to these diseases:

aspergillus
penicillium
fusarium
rhizopus

No chemical controls are used, but growers concentrate on management methods, such as drying seed.

The 1992 pesticide use estimates for vegetable seed crops are found in Table 19.

Table 18. Pesticides Use Estimates for Oregon Flower Seed Crops, 1992. 2,000 acres.

Common Name	Trade Name	Normal Rate of Application	Normal Method of Application	Acres Treated	Pounds Used a.i.
WEED CONTROL					
>>>>>>>seedbed preparation					
Glyphosate	Roundup	1.0 qt/acre	foliar	1,400 (70%)	1,400
Paraquat	Gramoxone	1.0 qt/acre	foliar	600 (30%)	600
Trifluralin	Treflan	1.0 - 2.0 pt	incorporate	1,600 (80%)	1,500
EPTC	Eptam	3.5 pt/acre	incorporate	200 (10%)	700
>>>>>>>post-planting - grasses and volunteer grains					
Sethoxydim	Poast	1.0 - 1.5 pt/acre	foliar	800 (40%)	190
Fluazifop butyl	Fusilade	0.75 - 1.0 pt/acre	foliar	200 (10%)	50
>>>>>>>post-planting - thistles, brassicas, annual bluegrass, chickweed, knotweed					
Napropamide	Devrinol	4.0 lb/acre	soil	600 (30%)	1,200
Pendamethalin	Prowl	0.5 - 1.5 qt/acre	soil	200 (10%)	200
Pronamide	Kerb 50W	0.5 - 1.5 lb/acre	soil	100 (05%)	50
Bentazon	Basagram	0.75 - 1.0 qt/acre	foliar	20 (01%)	20
Clopyralid	Stinger	1.0 - 2.0 lb/acre	spot	20 (01%)	20
Oxyflurofen	Goal 1.6E	1.0 - 2.0 pt/acre	soil	200 (10%)	60
Glyphosate	Roundup	1.0 qt/acre	foliar	600 (30%)	600
Paraquat	Gramoxone	1.0 qt/acre	foliar	200 (10%)	200
DISEASE CONTROL					
>>>>>>>*Anthracnose*, powdery mildew, pythium, *Septoria*, leaf spot, *Botrytis*, downy mildew					
Benomyl	Benlate 50W	0.5 - 1.5 lb/acre	foliar	400 (20%)	200
Captan	Captan, Orthocide	2.0 - 4.0 lb/acre	foliar	200 (10%)	600
Mancozeb	Manzate 200, Dithane	1.0 - 2.0 qt/acre	foliar	400 (20%)	600
Chlorothalonil	Bravo	2.0 - 3.0 pt/acre	foliar	600 (30%)	1,200
Vinclozolin	Ronilan	0.5 - 1.0 lb/acre	foliar	200 (10%)	100
Iprodione	Rovral	0.5 - 1.0 lb/acre	foliar, soil	200 (10%)	100
Fosetyl-Al	Chipco Aliette	5.0 lb/acre	drench	100 (05%)	5
Metalaxyl	Ridomil, Apron	0.5 - 1.0 lb/acre	foliar, soil	600 (30%)	300
Triadimefon	Bayleton	0.25 - 0.5 lb/acre	foliar	400 (20%)	100
Sulfur	Sulfur Dust	5.0 lb	lay-by	100 (05%)	500
INSECT CONTROL					
>>>>>>> aphids, *Lygus*, 12-spotted beetle, thrips, sphinx moth, mites					
Diazinon	AG500	1.0 - 2.0 qt/acre	foliar	800 (40%)	1,200
Endosulfan	Thiodan	1.0 - 2.0 qt/acre	foliar	200 (10%)	100
Azinphos-methyl	Azinphos methyl 2	1.0 - 2.0 qt/acre	foliar	200 (10%)	100
Chlorpyrifos	Lorsban 4E	1.0 - 2.0 qt/acre	foliar	400 (20%)	400
Propargite	Comite	1.5 - 3.0 lb/acre	foliar	100 (05%)	100

Table 19. Pesticides Use Estimates for Oregon Vegetable Seed Crops, 1992.

Common Name	Trade Name	Formulated Rate of Application	Normal Method of Application	Acres Treated	Pounds Used a.i.
RADISHES, Daikons and Red					
400 acres					
PREPLANT					
>>>>>>>seedbed preparation					
Trifluralin	Treflan	1.0 - 2.0 pt/acre	broadcast	400 (100%)	380
SPRING PLANTING					
>>>>>>>cabbage maggot					
Chlorpyrifos	Lorsban 15G, 4E	0.3 - 0.6 lb/1000 ft	in furrow	360 (90%)	470
Fonofos	Dyfonate 10G	20 lb	broadcast	40 (10%)	80
SPRING - Post-emergence					
>>>>>>>germinating weeds					
2,4-DB	Butyrac	0.5 - 1.0 pt/acre	broadcast	240 (60%)	90
>>>>>>>downy mildew, white mold					
Vinclozolin	Ridomil 50W	1.0 - 2.0 lb/acre	foliar	80 (20%)	60
SPRING - SUMMER					
>>>>>>>cabbage maggot, diamondback moth, aphids, *Lygus*, beet leafhopper					
Diazinon	Diazinon 4EC	1.0 qt/acre	broadcast	360 (90%)	360
CABBAGE					
900 acres					
PREPLANT					
>>>>>>>seedbed preparation					
Trifluralin	Treflan	1.0 - 2.0 pt/acre	incorporate	900 (100%)	850
Metolachlor	Dual 8E	1.0 - 3.0 pt/acre	incorporate	90 (10%)	180
Oxyfluorfen	Goal 1.6E	1.0 - 1.5 pt	incorporate	180 (20%)	50
PLANTING					
>>>>>>>cabbage maggot					
Chlorpyrifos	Lorsban 15G, 4E	0.3 - 0.6 lb/1000ft	in furrow	900 (100%)	1,200
>>>>>>>symphylans					
Fonofos	Dyfonate 10G	20 lb/acre	broadcast	270 (30%)	540
FALL					
>>>>>>>bedstraw, wild radish, wild turnips, wild mustards, vetch, prickly lettuce, shepherdspurse, groundsel					
Simazine	Simazine 80W	1.0 - 2.0 lb/acre	soil	220 (25%)	220
Fluazifop butyl	Fusilade	0.75 - 1.0 pt/acre	spot treat	220 (25%)	30
>>>>>>>cabbage maggot, cutworms, loopers					
Chlorpyrifos	Lorsban 4E	1.0 qt/acre	broadcast	180 (20%)	180
>>>>>>>cabbage aphid					
Azinphos-methyl	Azinphos methyl 2	1.0 qt/acre	foliar	360 (40%)	180

Table 19. Continued.

Common Name	Trade Name	Formulated Rate of Application	Normal Method of Application	Acres Treated	Pounds Used a.i.
WINTER					
>>>>>>>winter annuals					
Oxyflurofen	Goal 8E	1.0 - 2.0 pt/acre	incorporate	90 (10%)	90
Simazine	Simazine 80W	1.0 - 2.0 lb/acre	soil	90 (10%)	60
EARLY SPRING					
>>>>>>>white mold					
Benomyl	Benlate 50W	1.0 lb/acre	foliar	630 (70%)	320
Chlorothalonil	Bravo	2.0 - 3.0 pt/acre	foliar	810 (90%)	500
Iprodione	Rovral 50W	1.0 lb/acre	foliar	270 (30%)	140
SPRING					
>>>>>>>cabbage seedpod weevil					
Fluvalinate	Spur	0.05 - 0.1 lb/acre a.i.	foliar	810 (90%)	80
>>>>>>>flea beetles					
Endosulfan	Thiodan 50W	2.0 lb/acre	foliar	90 (10%)	90
>>>>>>>white mold					
Benomyl	Benlate 50W	1.0 lb/acre	foliar	630 (70%)	320
Chlorothalonil	Bravo	2.0 - 3.0 pt/acre	foliar	810 (90%)	1,000
Iprodione	Rovral 50W	1.0 lb/acre	foliar	270 (30%)	140
>>>>>>>slugs					
Metaldehyde		10-20 lb	perimeter	450 (50%)	180
CARROT SEED					
1700 acres					
SEED TREATMENT					
>>>>>>> alternaria					
Thiram	Thiram		seed coating	80% treated	10
Metalaxyl	Apron		seed coating	80% treated	10
PREPLANT					
>>>>>>>seedbed preparation, summer annuals					
Trifluralin	Treflan	2.0 - 3.0 pt	incorporate	1,700 (100%)	1,500
LATE SUMMER					
>>>>>>>summer annuals					
Linuron	Lorox 50W	1.5 - 3.0 lb/acre	broadcast	680 (40%)	680
Fluazifop-butyl	Fusilade	0.75 - 1.0 pt/acre	spot spray	850 (50%)	100
FALL - central Oregon					
>>>>>>>cutworms					
Chlorpyrifos	Lorsban 4E	1.0 qt/acre	broadcast	850 (50%)	850

Table 19. Continued.

Common Name	Trade Name	Formulated Rate of Application	Normal Method of Application	Acres Treated	Pounds Used a.i.
EARLY SPRING - prebloom					
>>>>>>> variegated cutworms, thrips, aphids					
Chlorpyrifos	Lorsban 4E	1.0 qt/acre	broadcast	340 (20%)	340
Methomyl	Lannate	1.0 - 2.0 pt/acre	broadcast	170 (10%)	150
SPRING					
>>>>>>>Xanthomonas bacterial blight, white mold, *Alternaria*					
Copper	Kocide 606	1.0 - 3.0 lb/acre	foliar	1,360 (80%)	2,700
Chlorothalonil	Bravo	2.0 - 3.0 pt/acre	foliar	340 (20%)	430
Iprodione	Rovral 50W	1.0 lb/acre	foliar	340 (20%)	170
>>>>>>>grasses					
Fluazifop-butyl	Fusilade	0.75 - 1.0 pt/acre	spot spray	340 (20%)	20
LATE MAY - eastern Oregon					
>>>>>>>Xanthomonas bacterial blight, white mold, *Alternaria*					
Copper	Kocide 606	1.0 - 3.0 lb/acre	foliar	340 (20%)	680
Chlorothalonil	Bravo	2.0 - 3.0 pt/acre	foliar	170 (10%)	210
Iprodione	Rovral 50W	1.0 lb/acre	foliar	170 (10%)	85
MID-JUNE - eastern Oregon					
>>>>>>>Xanthomonas bacterial blight, white mold, *Alternaria*					
Copper	Kocide 606	1.0 - 3.0 lb/acre	foliar	340 (20%)	680
Chlorothalonil	Bravo	2.0 - 3.0 pt/acre	foliar	170 (10%)	210
Iprodione	Rovral 50W	1.0 lb/acre	foliar	170 (10%)	85
SUMMER					
>>>>>>>summer annual weeds					
Linuron	Lorox 50W	1.5 - 3.0 lb/acre	soil	1,700 (100%)	1,900
JULY					
>>>>>>>*Lygus*, spider mites					
Bifenthrin	Capture	0.06 - 0.1 lb/acre a.i.	foliar	1,500 (90%)	150
AUGUST					
>>>>>>>*Lygus*, spider mites					
Mevinphos	Phosdrin 4EC	0.5 - 1.0 pt/acre	broadcast	170 (10%)	85
Chlorpyrifos	Lorsban 4E	1.0 qt/acre	foliar	680 (40%)	680
Fluvalinate	Spur	0.075 - 0.15 lb/acre a.i.	foliar	85 (05%)	10
Malathion	Malathion 8	1.0 pt/acre	foliar	170 (10%)	170
Bifenthrin	Capture	0.06 - 0.1 lb/acre a.i.	foliar	170 (10%)	20
Esfenvalerate	Asana XL	0.2 lb/acre a.i.	foliar	85 (05%)	20

Table 19. Continued.

Common Name	Trade Name	Formulated Rate of Application	Normal Method of Application	Acres Treated	Pounds Used a.i.
ONIONS					
300 acres					
PREPLANT - July					
>>>>>>>seedbed preparation					
Bensulide	Prefar 4E	3.0 - 6.0 qt/acre	broadcast	270 (90%)	1,200
DCPA	Dacthal 75W	8 - 12 lb/acre	broadcast	30 (10%)	230
>>>>>>>onion maggot					
Chlorpyrifos	Lorsban 15G	0.03 lb a.i./1000 ft	in furrow	45 (15%)	200
Diazinon	Diazinon 10G	20 lb/acre	in furrow	3 (01%)	6
POST-PLANT					
>>>>>>>germinating summer annual weeds and grasses					
Glyphosate	Roundup	1.0 qt/acre	broadcast	270 (90%)	270
JULY					
>>>>>>>					
Oxyfluorfen	Goal 1.6E	1.0 - 2.0 pt/acre	broadcast	270 (90%)	80
Bromoxynil	Buctril	1.0 - 1.5 pt/acre	broadcast	270 (90%)	90
JULY - SEPTEMBER - applied 4 - 5 times					
>>>>>>>thrips					
Mevinphos	Phosdrin	0.5 - 1.0 pt/acre	foliar	30 (10%)	70
Cypermethrin	Ammo, Cymbush	0.2 lb a.i./acre	foliar	180 (60%)	160
Permethrin	Pounce, Ambush	0.2 lb a.i./acre	foliar	90 (30%)	90
Lambda-cyhalothrin	Karate	0.05 - 0.1 lb a.i./acre	foliar	15 (05%)	10
Methyl parathion	Penncap M	0.75 qt/acre	foliar	30 (10%)	110
Malathion	Cythion	1.0 lb/acre	foliar	30 (10%)	90
Methomyl	Lannate	1 - 2 pt/acre	foliar	30 (10%)	60
SEPTEMBER					
>>>>>>>purple blotch, downy mildew, fusarium, pink root					
Chlorothalonil	Bravo	2.0 - 3.0 pt/acre	foliar	270 (90%)	340
Metalaxyl	Ridomil 50W	1.0 lb/acre	foliar	270 (90%)	140
Sulfur		3.0 - 6.0 lb/acre	side dress	90 (30%)	400
FALL					
>>>>>>>winter annuals					
Pendamethalin	Prowl	0.5 - 1.5 qt/acre	broadcast	30 (10%)	30
SPRING - sequential applications every 2 - 3 weeks for 5 weeks					
>>>>>>>downy mildew					
Mancozeb	Dithane M45	2.0 - 3.0 lb/acre	foliar	270 (90%)	540
+ Copper	Kocide	1.0 - 2.0 lb/acre	foliar	270 (90%)	400
Chlorothalonil	Ridomil/Bravo 81W	1.5 - 2.0 lb/acre	foliar	270 (90%)	390
+ Metalaxyl			foliar	270 (90%)	25

Table 19. Continued.

Common Name	Trade Name	Formulated Rate of Application	Normal Method of Application	Acres Treated	Pounds Used a.i.
SPRING - **sequential applications with each fungicide treatment**					
>>>>>>>thrips					
Cypermethrin	Ammo, Cymbush	0.2 lb a.i./acre	foliar	180 (60%)	35
Permethrin	Pounce, Ambush	0.2 lb a.i./acre	foliar	90 (30%)	20
Lambda-cyhalothrin	Karate	0.06 - 0.1 lb a.i./acre	foliar	15 (05%)	2
SPRING					
>>>>>>>grasses					
Pendimethalin	Prowl	0.5 - 1.5 lb/acre	broadcast	30 (10%)	15
Fluazifop butyl	Fusilade	0.75 - 1.0 pt/acre	foliar	30 (10%)	10
Sethoxydim	Poast	1.0 - 1.5 pt/acre	foliar	30 (10%)	10
Oxyfluorfen	Goal 1.6E	1.0 - 2.0 pt/acre	broadcast	15 (05%)	5
+ Bromoxynil	Buctril	1.0 - 1.5 pt/acre	foliar	15 (05%)	5
POST-BLOOM					
>>>>>>>*Botrytis*					
Chlorothalonil	Bravo	2.0 - 3.0 pt/acre	foliar	240 (80%)	300
Iprodione	Rovral 50W	1.0 lb/acre	foliar	30 (10%)	15
SWEET CORN					
500 acres					
PREPLANT - Spring					
>>>>>>>seedbed preparation, millet					
Metolachlor	Dual 8E	1.5 - 3.0 qt/acre	broadcast	150 (30%)	790
Alachlor	Lasso	2.0 - 4.0 qt/acre	broadcast	350 (70%)	500
>>>>>>>seed corn maggot, wireworm					
Chlorpyrifos	Lorsban 15G	0.075 lb a.i./1000 ft	in furrow	300 (60%)	1,600
Terbufos	Counter 15G	6.0 - 13.0 lb	in furrow	200 (40%)	300
SUMMER - 2 to 4 treatments					
>>>>>>>corn earworm, spider mites, western bean cutworm					
Carbaryl	Sevin XLR	1.5 qt/acre	foliar	200 (40%)	900
Esfenvalerate	Asana	0.025 - 0.05 lb a.i./acre	foliar	200 (40%)	25
Bacillus thuringiensis	Dipel	1.0 - 2.0 qt/acre	foliar	50 (10%)	45
Permethrin	Ambush	0.1 - 0.2 lb a.i./acre	foliar	50 (10%)	10
>>>>>>>penicillium, aspergillus, fusarium, rhizopus					
No effective chemical treatments					

Hops

Production

Hops, one of the oldest established crops in Oregon, were raised as early as the 1840's. The first commercial hops were planted near Silverton in Marion County in about 1857. Production was limited to home use and to the demands of local breweries. The major commercial use from early times has been in brewing beers. By 1870, hops were marketed in England. In the late 1890's, wholesale firms from the eastern United States and England paid over $1.5 million annually for Oregon hops. By the turn of the century, Marion, Polk, Yamhill, and Clackamas counties were producing over 1 million lb a year. Marion County led the way with just over 6,000 acres in production.

Climate and soil conditions in the Willamette Valley are favorable for producing large yields of high quality hops. New York was the major growing area for hops until the 1890's when the rapid acreage increase on the Pacific Coast eventually took the market. Oregon's production increased rapidly, starting in about 1889, and Oregon led the nation until 1915 when California took the lead for a few years. The rapid increase in beer output was largely responsible for the upward trend in United States hop production in the two decades surrounding the turn of the century.

Prohibition 1917-1933

In 1917, the adoption of the 18th amendment banning the sale of alcoholic beverages caused production to drop to 5 million lb. In 1918, production decreased to 3.5 million lb. Production increased slowly until 1923, mostly due to export. The hop yards in Europe had been neglected during World War I, but with the armistice, European production grew rapidly, creating a glut on the market. This limited further expansion of the Oregon hop acreage. Oregon yields lagged behind Washington and California from 1890 to 1930, in part because hops in those states were grown under irrigation on moist bottomlands, while in Oregon, a third of the acreage was located on poorer soils. Oregon hops grown on rich bottomlands yielded on a par with Washington and California hops.

In July 1933, Oregon joined other states in repealing the 18th amendment, and by the end of the year, prohibition ended. Domestic markets began to expand. Brewery hops in the United States totaled 14 million lb in 1916, 6 million in 1920 and under 2 million in 1931. With the end of

Figure 16. Annual Acres of Oregon Hops Harvested, 1880-1990.*

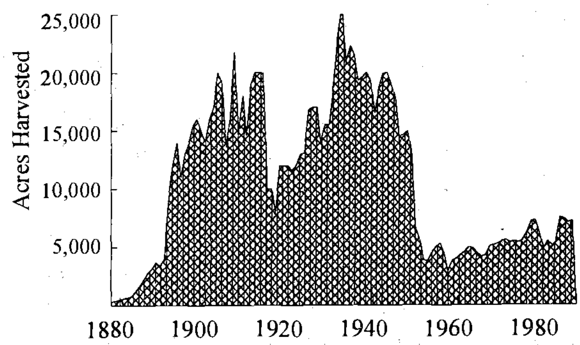


Figure 17. Annual Production of Oregon Hops Harvested, 1880-1990.*

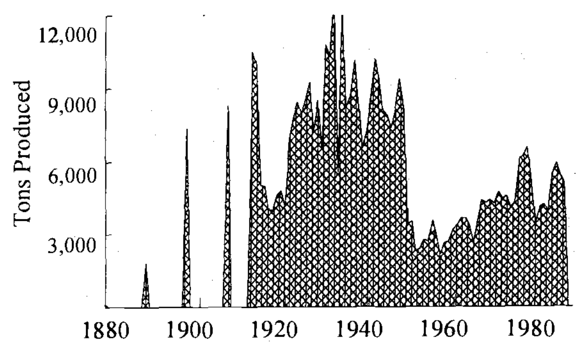
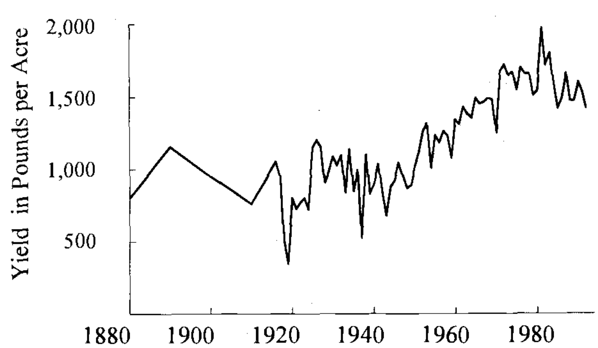


Figure 18. Annual Average Yield of Oregon Hops, 1880-1990.*



* Information compiled from Oregon State Agricultural College, SB 288, June 1931, for 1915-1930; Field & Seed Crops, Annual Crop Summary, Bureau of Ag Econ, USDA, for 1920-1950; U.S. Hops, Acreage, Yield, Production, Price, and Value of Production 1950 to Date, Washington Hop Commission.

prohibition, Oregon hop production increased to over 21 million lb. Oregon hop acreage climbed to an all-time high of 26,000 in 1935, which represented two-thirds of the national total. In 1936, hop production fell to about 11 million lb but rebounded the following year. However, the damage had been done. Prices were at an all-time low of 9.9 cents a lb in 1935 and placed many growers in an unfavorable financial position.

Most hops are grown in Marion and Polk counties, a district that has always dominated production in Oregon. Even so, during poor years that land remained idle. In 1930, for example, about 2,100 acres of mature hops were not harvested, and an additional 1,300 acres were plowed under because of poor prices. No commodity is quite so limited to a single use; hence, the violent fluctuations in price and the consequent losses in years with large surpluses or poor quality. Figures 16, 17, and 18 show hop acreage, production, and yield fluctuations over the past 110 years.

Historical Pesticide Use

The use of pesticides on hops in Oregon and the Pacific Northwest as shown in Figure 19 began with the application of "old time" materials. Although this is not an all-inclusive list, it does show what pesticides were in general use during this century.

1890's

Up until 1890, diseases and insects were not of great concern to Oregon hop growers. Then in 1890, the hop aphid was found in a Lane County hop yard along the MacKenzie River. Soon aphids spread to other hop yards throughout the Willamette Valley. In the years following, losses were estimated at one-twelfth of annual production. Control remedies included cleaning up hop yards, burning vines immediately after harvest, and removing any alternate hosts in the area such as prunes and plums. Growers were encouraged, when possible, to spray the hops with quassia and soap, kerosene emulsion, or a tobacco soft soap solution. Quassia, a tree native to the Caribbean area, contains *quassin,* a toxin with insecticidal value. Farmers boiled 5 lb of quassia wood chips in 100 gallons of water, extracted the toxin, and mixed it with soap so that it would spread over the leaf surface. Tobacco stems and wastes were purchased for a few cents a pound. The nicotine was extracted and used in much the same manner as quassia. Kerosene emulsion was often made with whale oil soap and, like the other chemical remedies, was normally formulated at the farm. These "homegrown" formulations varied and sometimes resulted in no control or severely burned plants. Quassia, used until the mid-1930's, and nicotine, used until the mid-1950's, were both excellent aphicides.

In 1892, the twospotted spider mite (known also as the red spider mite) first appeared as a major pest on hops, causing serious injury under specific conditions. Low temperatures and moisture are detrimental to spider mites, while high temperature and drought are ideal. Some form of sulfur was commonly used to treat mites. By the early 1920's, sulfur dust was used when temperatures were high and the mites had not spun their webs effectively. Otherwise, liquid spray was used. By stripping off the lower leaves, growers were often able to delay a serious infection. Burning, plowing, or using a weed killer to destroy vegetation around hop yards helped keep mite populations under control.

1929

Downy mildew first appeared in western Washington in 1929 and quickly spread into other hop growing areas. By 1933, annual mildew damage in the Pacific Northwest was estimated at 1 million dollars, and Bordeaux spray mixture was used to control it. Early season Calcium Cyanamid treatments on the plant crowns was common. Application of about 2 ounces of Calcium Cyanamid per hill worked both as a fungicide and a fertilizer, but because it was phytotoxic, it could not be applied once the spikes emerged. Often, copper-lime was applied to the hill to control mildew as the hop spikes emerged from the crown. Efficient spraying was essential to guarantee first quality hops. Downy mildew became the greatest problem facing the hop grower and has remained so ever since.

When large quantities of Bordeaux, quassia, lime sulfur, nicotine, and other sprays were needed, growers often formulated their own sprays on the farm. Lack of uniformity of these emulsions and other formulations often reduced control of downy mildew, aphids, or mites. In addition, applying dust was a lot simpler than applying liquid sprays. As a result, dust formulations became popular in the mid-1930's. Quassia could not be used as a dust because it was only formulated as a liquid. Bordeaux, copper, sulfur, nicotine and others were formulated as dusts and applied both by ground and air. Sulfur was first dusted by air in 1931 for spider mites, but it did not offer much control. In 1933, nicotine dust was first applied for aphids. Dusts were the dominant pesticide formulation until the early 1950's.

1936 was an especially bad year for mildew and cutworms. Copper-lime dusts supplanted Bordeaux, but no adequate control for mildew had been found. Poison arsenate and arsenite baits were used to control the cutworms. About 1935, the hop industry underwent changes in pest control operations. Acreage expanded, and nicotine dusts were supplanting quassia and nicotine sprays for aphid control. Lime sulfur sprays and oil sprays were no longer effective against the red spider mite. By the late 1930's, aphid control was estimated to cost $1 million a year.

DN dusts, developed just before the war, began to be used in place of sulfur for mite control. Because dusters were still rather primitive, it took 40 to 50 lb of DN dust to do the job that 12 to 16 lb should do.

Post War

Better application machinery was needed to apply dusts, but when the United States entered World War II, machinery was hard to get. By 1944, the supply of nicotine sulfate was well below growers' needs, and alternative aphicides, such as quassia, were used. The inability of growers to find adequate aphicides became critical because the Pure Food and Drug Administration was seizing hops that contained excessive aphids. Pyrethrum was not readily available because the war curtailed most international shipping. The nicotine shortage continued into the 1950's. The war also caused a copper shortage. Copper-lime dusts were in short supply and had to be mixed with zinc sulfate, hydrated lime, or bentonite sulfur.

After the war, new pesticide developments altered grower usage habits. Vapatone, an early brand name for TEPP, was used as a replacement for nicotine for aphid control. Because the dust formulation of TEPP was less effective, growers needed to buy special equipment to apply TEPP as an aerosol.

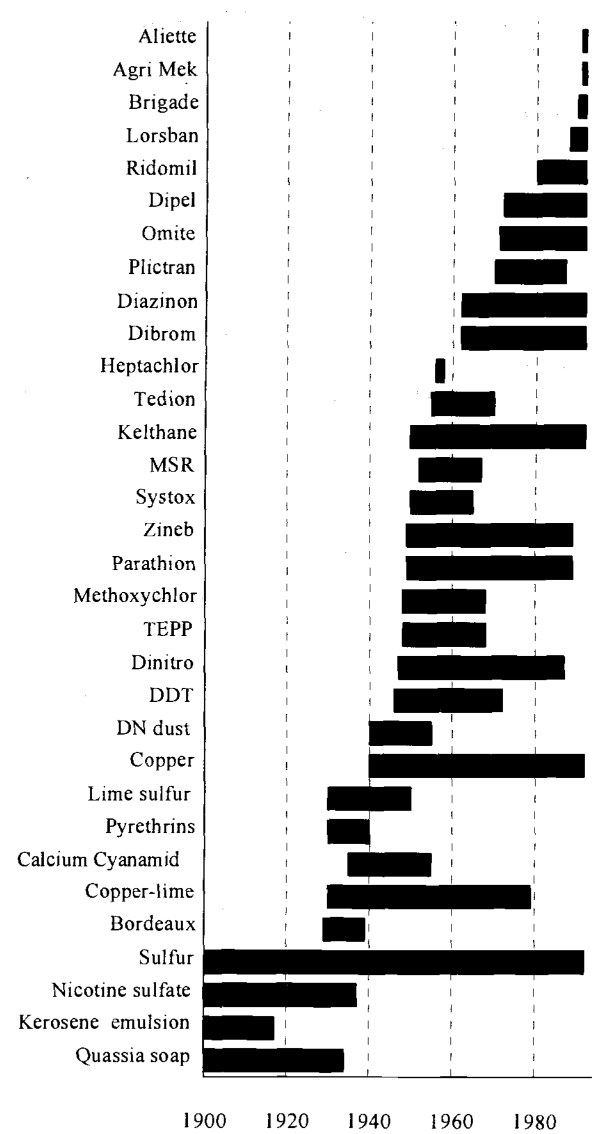
By 1949, parathion dust was discovered to control red spider mites, and soon others, including TEPP, demeton, and dinocap (Kelthane), were added to the spider mite arsenal. DN dusts were still the mainstay of mite control. TEPP and parathion also were added to the hop aphid arsenal. DDT and methoxychlor were used against leaftiers and cutworms. Metasystox-R, Schraden, and Systox were used somewhat for aphid control in the 1950's and 1960's. However, TEPP dust applied by air was the mainstay for aphid control. The record for use of highly toxic insecticides on hops is excellent. However, because of the acute toxicity of TEPP dust and the inherent problems with drift, its use was discontinued in the late 1960's.

In 1952, mite resistance to TEPP and parathion was found in Washington and California, and growers changed to Aramite 88R (a sulfur product) to control resistant mites. That same year, a worldwide sulfur shortage resulted in an increase in the use of Dithane Z-78 (zineb), which had been available as a mildew control fungicide since 1949.

The black vine weevil was a serious pest in areas of Oregon and Washington. In 1956 and 1957, heptachlor was applied to control this insect. Heptachlor, however, is quite toxic to the hop plant, and hop yards treated with this chemical were pulled out of production. These old heptachlor treated lands still cannot be replanted in hops.

It has been the practice for growers to strip the lower leaves from the vines to control excess shoot growth. Dinitro was used for 40 years as a chemical stripper until it was canceled. Since then, Des-I-Cate or Gramoxone has been used. Stripping is also a method of mite control. Mites moving up from the ground will first attack these lower leaves. Leaf removal delays the onset of the mite season, especially when dinoseb is used. When dinitro-o-cresol was first introduced into the United States from France in the early 1930's, it was used primarily as a miticide. Various kinds of dinitro were later developed into growth regulators (Elgetol) and herbicides (dinoseb). When dinoseb was applied to the crown and lower vines, it also killed mites and left a residue on the soil which delayed mite invasion for several weeks. Dinoseb also controlled downy mildew by killing the fungus by contact action and by removing new spikes emerging from

Figure 19. Prominent Pesticides Used on Hops with General Period of Use.



the hills. When dinoseb registration was canceled, these benefits were lost.

When parathion and TEPP were first available, both controlled mites very well. However, resistance built up very quickly; soon neither product was effective. Tedion and Kelthane came into general use afterward, but by the mid-1960's, resistance built up to these as well.

Aphids were controlled by TEPP and parathion throughout the 1950's. When diazinon was registered for hops in the mid-1960's, it became the aphicide of choice. While resistance to diazinon in Europe was such that it was ineffective in aphid control, this was not the experience in the Pacific Northwest, and diazinon is still the primary insecticide used in hop aphid control.

EPA Era

In 1971, one year after the Environmental Protection Agency was created, the miticide Omite was registered for hops, and 3 years later, Plictran was registered. These were important because mites had become resistant to Kelthane. Omite and Plictran were used in alternate years to avoid resistance buildup. After four years, the mites would become susceptible to Kelthane once again, and Kelthane could be used only as a backup. Omite was phytotoxic to several hop varieties, but Kelthane could be used for early season control and would not injure the tender plants. Since then, the newer Omite formulation has proved to be less phytotoxic than the Omite CR. In the late 1970's, some initial experimental use permit work was done with Carzol and Temik for mite and aphid control, but no labels were forthcoming. Under the experimental use permit, Temik was shanked into the ground in the root zone of the hops. Temik provided excellent early season aphid control.

Plictran use was dropped worldwide in about 1987. This left the hop growers with Kelthane and Omite, which had become unreliable. As a result, in 1991-1992, Abamectin was given an emergency registration (Section 18) to aid in mite control.

Brigade was granted emergency registration for aphid control in 1990, 1991, and 1992. It is used primarily in the Yakima Valley.

During the season, each hop row is cultivated four to six times in each direction in order to keep soil in good condition and to keep weeds under control. After the final cultivation in July, further weed control must be done by hand. As a result of these current practices, herbicides are not used in weed management of an established hop yard during the growing season. Gramoxone and Solicam, however, are applied during the dormant period to control winter annuals and some perennial noxious grasses such as quackgrass.

Table 20. Pesticide Use Comparisons for Oregon Hops, 1981, 1987, 1992.

Herbicides	**1981**	**1987**	**1992**
Dinoseb	9,000	—	—
Endothall	—	—	600
Norflurazon	—	550	2,200
Paraquat	2,000	260	2,200
Insecticides	**1981**	**1987**	**1992**
Abamectin	—	—	88
Chlorpyrifos	—	—	7,800
Cyhexatin	3,000	—	—
Demeton	500	—	—
Diazinon	2,000	—	16,000
Dicofol	2,000	—	2,200
Oxydemeton methyl	500	—	—
Propargite	2,000	—	14,000
Fungicides	**1981**	**1987**	**1992**
Copper	—	4,000	40,000
Fosetyl-Al	—	—	32,000
Metalaxyl	500	1,700	3,900
Zineb	1,000	9,200	—
Plant Growth Regulators	**1981**	**1987**	**1992**
Gibberellic acid	—	—	5

Currently Brigade, Lorsban, Agri-Mek, and Aliette are registered under Section 18.

A comparison of pesticides applied to hops for the years 1981, 1987, and 1992 is found in Table 20.

Pest Control Management Practices

Around the first of April, growers apply Ridomil or Aliette to help control downy mildew. Kocide or some other copper hydroxide product is tank mixed with them. The more susceptible varieties are usually treated with Aliette plus copper for a second time in early May and again a third time in mid-July. There is documented evidence that downy mildew is resistant to Ridomil in some areas, but not area wide. Therefore, Ridomil is applied no more than once per year. Aliette, under a Section 18, can be applied to aid the grower in avoiding insect resistance to Ridomil.

Summer pests must be controlled to retain yields and quality. The twospotted spider mite is the most common mite pest on hops in Oregon, Washington, and Idaho. It is also the toughest to control. It is a summer pest and arrived earlier in 1992 because of the warm, early season. A majority of the growers apply Omite around the 20th of June. Others use Kelthane, which is less expensive but also less effective because some pests have been resistant to it since the late 1950's. However, when populations are small, Kelthane is often used instead of Omite, which is also losing effectiveness against the twospotted mite. If mites become a serious problem following application of Omite or Kelthane, growers often use Agri-Mek, registered under Section 18. Others will continue to apply Omite, but none will use Kelthane. Agri-Mek will give 6 to 8 weeks of control; Omite will give only 3 weeks of control. By August, growers must decide whether to spray one more time for mites because at this time, mites begin moving from the leaves to the cones. In 1992, an early dry season resulted in more growers using Agri-Mek. They also applied the miticides about a month earlier than normal.

Aphids secrete a honey dew on which sooty mold grows, resulting in black cones that are not marketable. Because aphids cause yield reductions, they are treated with several pesticides. Three treatments are made: one in June, one in July, and one in August. In Oregon, most growers use diazinon on the first application. For the second and third applications, many use Lorsban instead. Loopers, another hop pest, are generally killed by the aphid treatments. If they persist, Dibrom or Dipel may be used.

In mid-March, Gramoxone is applied in 2-foot bands to control winter annuals. Solicam is used as a spot treatment, especially for quackgrass. Some spot treatments are done with Des-I-Cate to burn down weeds and spikes during the growing season. Because hops are cultivated regularly, only a small quantity of herbicides are used. One variety of hops that covers 300 to 400 acres requires one application of Pro-Gibb.

Table 21 contains the 1992 pesticide use estimates for hops.

Table 21. **Pesticides Use Estimates for Oregon Hops, 1992. 7900 acres.**

Common Name	Trade Name	Formulated Rate of Application	Method of Application	Acres Treated	Pounds Used a.i..
DORMANT - March 15					
>>>>>>>Pests: winter annual weeds					
Paraquat	Gramoxone	1.0 lb/acre	banded	7,900 (100%)	2,200
>>>>>>>Pests: perennial grasses, quackgrass					
Norflurazon	Solicam DF	2.5 - 5.0 lb/acre	spot treatment	7,900 (100%)	1,600
EARLY SPRING - April 1					
>>>>>>>Pests: downy mildew					
Metalaxyl	Ridomil 2E	2.0 qt/acre	air blast	3,900 (50%)	3,900
+ Copper	Kocide 101, Champ	2.0 lb/acre	air blast	3,900 (50%)	7,900
Fosetyl-Al	Aliette (Section 18)	2.5 - 5.0 lb/acre	air blast	3,900 (50%)	7,900
+ Copper	Kocide 101, Champ	2.0 lb/acre	air blast	3,900 (50%)	7,900
SPRING - May 1					
>>>>>>>Pests: downy mildew					
Fosetyl-Al	Aliette (Section 18)	2.5 - 5.0 lb/acre	air blast	6,000 (75%)	12,000
+ Copper	Kocide 101, Champ	2.0 lb/acre	air blast	6,000 (75%)	12,000
SPRING					
>>>>>>>Purpose of treatment: increase yield					
Gibberellic acid	Pro-Gibb	4.0 - 6.0 oz/acre	air blast	400 (5%)	6
SPRING - June 1					
>>>>>>>Pests: hop aphid, aphids, loopers					
Diazinon	Diazinon 50WP	1.0 lb/acre	air blast	7,900 (100%)	7,900
LATE SPRING - June 20					
>>>>>>>Pests: twospotted mites					
Propargite	Omite 30W	5.0 lb/acre	air blast	6,000 (75%)	8,900
Dicofol	Kelthane EC	2.0 - 2.5 pt/acre	air blast	2,000 (25%)	2,200
SPRING and SUMMER					
>>>>>>>Purpose of treatment: burn down hop seedlings and spikes					
Endothall	Des-I-Cate	1.0 - 2.0 gal/acre	Spot treatment	7,900 (100%)	600
SUMMER - July 4-10					
>>>>>>>Pests: twospotted mites					
Abamectin	Agri-Mek 0.15EC	1.0 - 2.0 fl oz/100 gal	air blast	4,700 (60%)	33
Propargite	Omite 30W	5.0 lb/acre	air blast	3,200 (40%)	4,700
>>>>>>> Pests: hop aphid, aphids, loopers					
Chlorpyrifos	Lorsban 4E	1.0 qt/acre	air blast	3,900 (50%)	3,900
Diazinon	Diazinon 50WP	2.0 lb/acre	air blast	3,900 (50%)	3,900

Table 21. Continued.

Common Name	Trade Name	Formulated Rate of Application	Method of Application	Acres Treated	Pounds Used a.i.
SUMMER BLOOM - July 15					
>>>>>>>Pests: downy mildew					
Fosetyl-Al	Aliette	2.5 - 5.0 lb/acre	air blast	6,000 (75%)	12,000
+ Copper	Kocide 101, Champ	2.0 lb/acre	air blast	6,000 (75%)	12,000
SUMMER - August 1					
>>>>>>>Pests: hop aphid, aphids, loopers					
Chlorpyrifos	Lorsban 4E	1.0 qt/acre	air blast	3,900 (50%)	3,900
Diazinon	Diazinon 50WP	2.0 lb/acre	air blast	3,900 (50%)	3,900
>>>>>>>Pests: twospotted mites					
Abamectin	Agri-Mek 0.15EC	1.0 - 2.0 fl oz/100 gal	air blast	7,900 (100%)	55

Peppermint

Production

Seventeenth century growers began peppermint cultivation in England, near Mitcham. Commercial production spread across northern Europe and, eventually, to the American colonies, where commercial production started in the 1770's. First centered in New York, the mint industry moved to Michigan and, finally, the west coast. Albert Todd, a Michigan chemist, developed a better oil purification distilling process that produced uniformly pure and high quality oil, allowing quality standards to be set.

Since the early days, disease and pests have prompted the movement of mint production. Today, most of the United States' peppermint and spearmint is grown in these states:

- Wisconsin
- Idaho
- Indiana
- Washington
- Oregon

In the beginning, there were many unknowns in mint growing. Because the mint industry was small, the USDA took no interest in it, and growers had to learn many things about mint production:

- Which crops work best in rotation?
- What chemicals provide adequate weed control?
- What kinds and amounts of fertilizer work best?
- What are the best types of soil for mint growing?
- When is the best time to cut mint?
- What are the proper distilling techniques?

In 1903, mint cultivation began in Idaho. Six years later, 20 acres were planted near Albany, Oregon, and within a few years, the mint industry was established in Oregon. Mint oil demand pushed planting, and by 1927, there were 200 acres of mint in Oregon. Acreage remained constant through the 1930's but expanded again as the export market increased. The widespread presence of verticillium wilt in the Midwest in the 1930's led to increased west coast production. The changes in harvested acreage, production, and yields of Oregon peppermint are shown in Figures 20, 21, and 22.

Following World War II, Oregon and Washington accounted for 40 percent of the oil produced in the United States. The Oregon Essential Oil Growers League helped Oregon growers prosper by providing leadership and assistance with farming and marketing problems.

Figure 20. Annual Acres of Oregon Peppermint, 1903-1992.

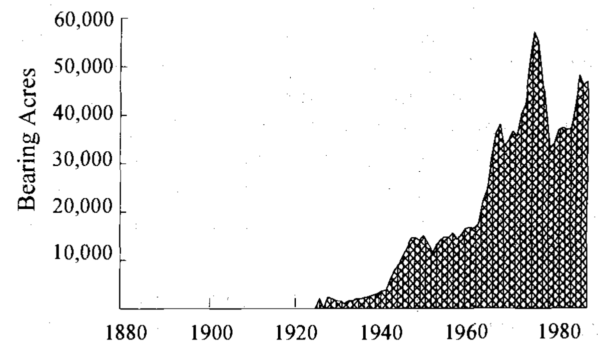


Figure 21. Annual Production of Oregon Peppermint Oil, 1903-1992.

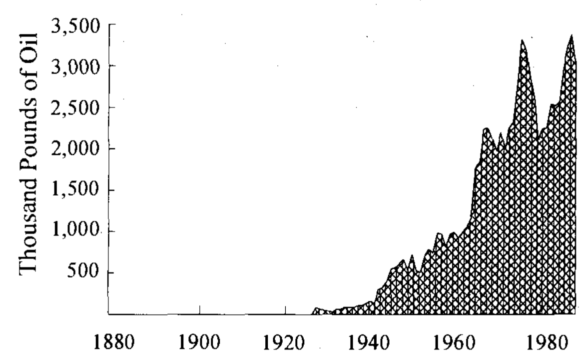
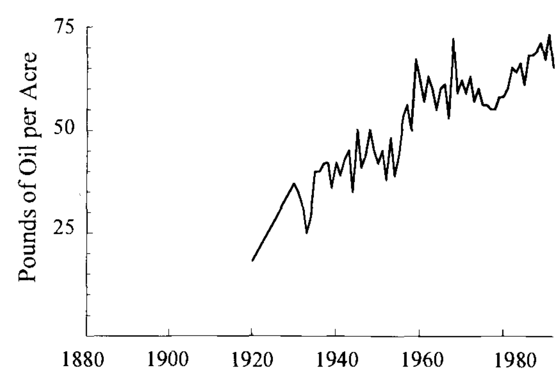


Figure 22. Annual Average Yields of Oregon Peppermint Oil, 1903-1992.



Extension Economic Information Office, OSU.

During the 1930's, about 40 percent of the mint oil was exported, but this decreased after the war. Dealers marketed mint oil and enjoyed a large share of the profits. Even without laboratories or field testing facilities, Oregon mint quality was high. During and after the Second World War, production increased, and new oil testing facilities were built. Substantial investments were made in equipment, laboratories, and technical know-how, and growers depended on dealers to buy and market their crops. Growth of the mint industry in central Oregon was rapid. The earliest plantings were in Deschutes County, but they were soon overrun by weeds. The hay was harvested and hauled to the Willamette Valley for processing. When verticillium wilt became a serious problem in the Willamette Valley in the early 1950's, growers moved into central Oregon, a clean area. However, winter injury, herbicide damage, and other factors resulted in less than 900 acres harvested. By 1959, about 70 growers had 3000 acres in production.

The price of peppermint varied greatly from year to year. Just after the war, mint prices soared from $10 to $16 per lb, only to plummet to less than $1 per lb as production increased.

The west coast oils, especially those in the desert regions, were distinctively different in flavor and odor than oils produced in the Midwest. Weeds altered the flavor as did improper distilling methods, but in the 1940's and 1950's, studies of distillation methods and harvest times in Oregon and Washington led to improved mint quality.

Today, Oregon produces about 50 percent of the nation's peppermint oil—oil that is used as flavoring for chewing gum, candy, toothpaste, and medicine.

Historical Pesticide Use in Mint

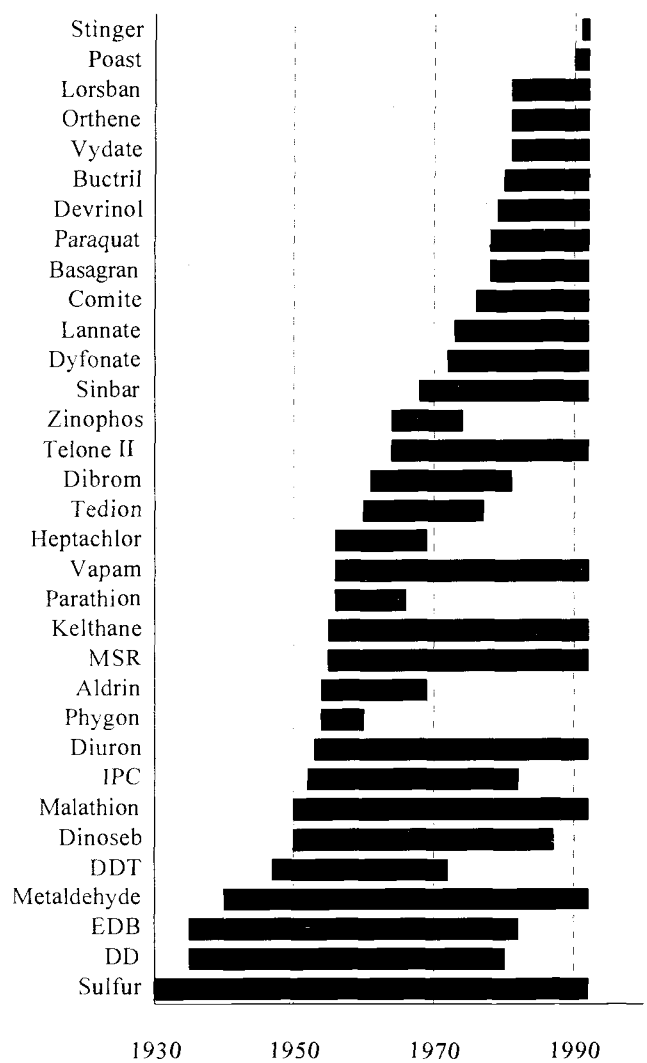
The use of pesticides on mint in Oregon and the Pacific Northwest, presented in Figure 23, began with a few inorganic chemicals and plant products. Although this is not an all-inclusive list and does not give amounts applied, it does show what chemicals were in wide use. General use of these early pesticides broadened after World War II as new pesticide products became available. This was an era of expansion of pesticide use. However, in the past decade, fewer new pesticide labels for mint have been registered than in any of the previous four decades.

There was little interest in peppermint breeding research until verticillium wilt was first observed in Michigan and Indiana. The traditional method of dealing with wilt was simply to move to a new area of the state where it had not become a problem. As a result of verticillium wilt, other pests, and poor farming practices, the mint industry finally migrated to the west coast. Old pest problems like wilt and the mint flea beetle, as well as new pest problems like the strawberry root weevil, became troublesome in the new plantings at Lake Labish in the Willamette Valley.

In 1949, peppermint rust was found in quantities large enough to substantially reduce yields in Columbia County, north of the Willamette Valley. In that county, all of the mint was infected with rust, but no rust was detected in the Willamette Valley until the following spring. By November, every field examined in the Willamette Valley was infected with rust, which caused a reduction in oil yield. Rust becomes especially prevalent when the spring is wet and cool.

Research on control of mint diseases began in 1951 through the Experiment Station. Several fungicides were

Figure 23. Prominent Pesticides Used on Peppermint with General Period of Use.



applied to test plots, primarily to determine whether or not the mint oil had undesirable characteristics. Specialists recommended that all mint fields be plowed under and that infected stubble be covered to control the rust. Dinitro was applied to areas where stubble could not be turned over. Wild mint (and any mint within 10 feet of the field) was sprayed with dinitro or with 2,4-D in an attempt to control rust.

In 1954, a Phygon dust was applied to mint early to delay the onset of rust disease. Growers who used Phygon properly increased their yields over the previous year. Community rust control practices were in effect at the end of the 1950's and included practices to reduce rust inoculum. One of these practices, burning mint stubble with propane torches, was just beginning to be used for rust control.

Verticillium wilt was first observed in Michigan mint in 1924; it was noted in Indiana in 1940. This disease became the limiting factor in Midwest mint production. Verticillium wilt was first observed in Oregon in 1946 at Lake Labish and, again, in 1951 near Talbot. By the late 1950's, it had spread throughout the Willamette Valley. Factors that aided the movement of wilt were infected root stocks, soil movement by equipment, and movement of inoculum by winter flooding. Deep plowing was recommended to help stem the spread of the disease. This was an attempt to escape the wilt infection by burying the heavily infested top layer of soil and replacing it with the deeper soil, which might be disease free.

The strawberry root weevil, black vine weevil, and rough strawberry root weevil caused problems early in the history of Oregon mint production. Variations in the development of each pest complicated control practices. One or more applications of calcium arsenate treated bait was sometimes sufficient to kill adult weevils as they emerged and before they could lay eggs. These baits were applied with seeders, fertilizer spreaders, or any other means available.

The mint flea beetle and strawberry root weevil were the most serious mint insect pests at the time. The adult mint flea beetle was controlled easily after DDT became available. In 1954, aldrin was registered for use on mint. It provided control for more than one year on mint flea beetle larvae and various weevils, but it had to be disked into the soil.

Wireworms had been a serious pest on many crops in Oregon. They were effectively controlled with the fumigant ethylene dibromide (EDB) or with aldrin. In 1956, growers began to use heptachlor against wireworms.

Variegated cutworms, alfalfa and cabbage loopers and other similar lepidopterous insects were occasional pests prominent about every four or five years. Several species of the cutworms, both soil and aerial, were treated with calcium arsenate treated baits. Soil cutworms fed at or beneath the soil surface while aerial cutworms normally climbed the mint and fed on the foliage. Loopers also fed on the foliage. As a result, baits were more effective in controlling the soil species. If present in sufficient numbers, both loopers and cutworms could be treated with DDT. DDT was applied either by air or through a sprinkler irrigation system. This was an inexpensive and effective application technique for controlling these pests.

In the 1950's, the garden symphylan was acknowledged to be a problem in the Willamette Valley. Previously, most entomologists had not considered it to be of economic importance. Because it lives in the deeper layers of the soil profile as well at the surface, soil fumigants such as DD or EDB could not control it. Such fumigants were shanked into the soil at levels around 18 inches, and symphylans too far above or below that area escaped control. As a result, growers simply endured symphylans. When weevils and wireworms were finally controlled by insecticides, symphylids were considered the most troublesome pest in western Oregon, where they caused considerable damage in Ontario mint crops in 1956. Fumigant control was possible only in the establishment year because once the mint was planted, DD mixture, EDB, and, later, Vapam could not be applied. Parathion soil treatment was used for short-term control and allowed plants to become established.

Slugs were occasional pests in wet years or when a cover crop was grown. Geese were known to eat slugs as well as weeds in the field. When geese were no longer used, metaldehyde baits were the only control employed.

Nematodes were a serious problem in many areas of Oregon, but in mint they were especially troublesome following a wet spring. Crop rotation was the best means of controlling this disease, and because of the other pest problems in mint, growers increasingly used this cropping practice.

Perennial and annual grasses and broadleaf weeds were (and still are) big problems in mint production. Weeds not only reduced yields but, more importantly, affected the oil flavor and odor. When weeds were distilled with mint, they imparted an off-flavor to the oil, lowering its value or making it unmarketable. Although not all weeds altered the flavor, several important weeds were commonly found in mint and were a challenge to control:

- bentgrass
- bluegrass
- Canada thistle
- knotweed
- lambsquarter
- mustard
- millet
- quackgrass

purslane
red root pigweed
smartweed

In the early 1950's, some of the perennial grasses were treated with IPC or TCA, but with limited success. Dinitro and oil were applied in combination to control seedling annual grasses and broadleaf plants. IPC was combined with an early formulation of diuron to treat annual grasses when prevalent. Calcium cyanamid was also used against annual weeds and had the added advantage of supplying nitrogen fertilizer to the plant.

It has been forgotten that perennial and biennial noxious weeds laid waste to hundreds of thousands of acres of prime farmland during the first half of the 20th century. Many of these weeds, which were not native, had spread all over Oregon and were well established. Some of the most troublesome weeds were the perennials: quackgrass, Canada thistle, and morning glory. No effective practices were available for morning glory, but fortunately only a few fields were infested with this noxious weed. It was commonly believed that Canada thistle could be suppressed wherever there was an exceptionally vigorous stand of mint to furnish competition. However, this was wishful thinking and could never be substantiated. Spot treatments with other inorganic nonselective herbicides to control Canada thistle and other hard to kill perennial weeds were rarely successful.

These weed populations had to be reduced, and modern herbicides challenged this weed problem. Dinitro amine used as a preemergent herbicide worked well on both grasses and broadleaf weeds when it was applied just after the mint was worked in the spring.

Cultivation was the best weed control in the early 1950's. Prior to chemical weed control, the common weed control practice was to plow and harrow mint fields in the fall or spring. Once the plants were too large to cultivate, geese or sheep were moved into the field. Animals prefer weeds to the mint. Generally, two geese or one sheep per acre were required and some supplemental feeding was necessary because geese did not fare well on weeds alone. Geese were effective in selective weed control because they ate a wide variety of species and greatly reduced the need for hoeing and the costs of this method. However, there were several disadvantages to using geese:

- They had to be readily available to (or raised by) the mint grower.
- Good fencing was needed to reduce the danger that they would eat nearby crops.
- Geese could also learn to eat mint.
- They could cause crop damage by trampling the field.
- Predators and disease could kill the geese.
- Geese did not eat older weeds or weeds such as purslane.
- Both geese and sheep helped spread verticillium wilt.

Sheep, however, would eat the older weeds as well as many weeds that geese refuse to eat. But sheep tended to eat the mint as well, and neither animal will eat purslane.

In the mid-1950's, Karmex DW became the standard preemerge treatment. When applied at high rates, it suppressed quackgrass but did not control it. Quackgrass, however, remained the worst weed in western Oregon peppermint, and there was no adequate chemical control. Yellow nutsedge also was a problem in mint fields at this time. Karmex (diuron) was still the established weed control chemical at the end of the 1950's, and no other chemicals were cheaper or more effective. Dinitro amine was often added to Karmex in order to maintain early rust control prior to mint emergence. The dinitro burned back any exposed mint on which rust had overwintered. This treatment generally had good results.

1960's

Verticillium wilt increased from 90 acres in 1951 to 7,500 acres in 1962. Nearly all fields had some infection. Most of the old mint plantings in the mid-Willamette Valley were infected with wilt, and by 1961, many older mint fields were taken out of production. New, uninfected land was planted, but it, too, began to show wilt infestation. At this time, several fields in central Oregon were found to have wilt for the first time. No wilt was found in Ontario, Oregon, and growers there formed a quarantine to prevent introduction of mint wilt. Decline in mint production at this time was directly correlated to wilt severity.

Three- to five-year crop rotations did not eliminate the wilt problem. However, other practices helped, especially planting clean rootstock. Chemical weed control, instead of plowing and cultivation, also reduced wilt pressure. Controlling mint rust by propane burning was discovered in 1963. Later, it was found that fall flaming helped stem the spread of verticillium wilt. This practice destroyed most wilt infection in mint stems, and it largely eliminated the mechanical spread of wilt that resulted when fields were plowed and cultivated. It also reduced the amount of inoculum in the soil.

A clean rootstock program was established, and growers expended considerable effort to make disease-free planting stock available.

The area around Madras in central Oregon did not adopt flaming as a cultural practice.

In 1965, spider mites in western Oregon mint fields were rare. But in central Oregon, the Atlantic mite was common, and the twospotted spider mite was increasing in numbers in many mint fields. At first, many growers used malathion. Tedion, a slow acting acaricide, was effective when mite populations were not high. Kelthane was used predominately, and it controlled spider mites very well, but in 1969, after several years of success, growers began to notice that twospotted spider mites were not adequately controlled by Kelthane. Reports of spider mite resistance to other insecticides were common knowledge, and although there was not hard data to substantiate genetic resistance to Kelthane, it was bantered about that spider mites were becoming resistant to it as well. Actual resistance was not documented until 1991. However, in the 1960s, Tedion was the only other registered miticide for use on mint that was considered effective. Malathion was no longer considered effective on mites.

Loopers and cutworms remained a problem in both the Willamette Valley and central Oregon. Dibrom and Sevin were introduced to control them in mint.

Long-term garden symphylan control was obtained with the fumigant Telone, but it was effective only when applied before mint was planted. Later infestations could be managed with the nematicide Zinophos, which was generally recommended by field consultants, and was applied each year. Zinophos could be applied to both new mint and established mint.

Aldrin and dieldrin were no longer recommended for root weevil control because application limitations made both chemicals ineffective. However, no other effective materials were available. Previously, aldrin and dieldrin had gradually supplanted cryolite and DDT dust for controlling the mint flea beetle. Substitute chemicals were being sought because only DDT, tedion, and malathion were available.

In 1964, specialists began testing Sinbar for weed control in mint, and it became evident that mint had a wide tolerance for Sinbar. Therefore, in 1968, Sinbar was registered for use on mint and became the basis for good weed control in mint.

New verticillium wilt tolerant varieties were undergoing field testing, and the first variety was finally released in January of 1972. It was recommended that only wilt-free stock be used for new plantings and that the ground be fumigated with Telone, D-D, or Vapam.

1970's

In 1971, the redbacked cutworm was recognized as a major pest problem in central Oregon, and Dyfonate bait was used to treat the aerial cutworm infestation in nearly 1000 acres of mint. For many years, growers had preferred to use DDT to control cutworms and loopers. In 1973, Lannate was registered for use against these two insects. The mint flea beetle, once considered a limiting factor in mint production, had been brought under control with DDT. However, when DDT was canceled, populations increased above economic thresholds and caused severe damage to mint in the Willamette Valley.

The mint root borer was a new pest and was found in damaging levels in the Hermiston area and the Willamette Valley in the early 1970's. No chemical controls were available, but growers could suppress the pest by plowing fields during the overwintering stage of the mint root borer.

When soil persistent insecticides like aldrin and dieldrin were discontinued, the strawberry root weevil populations rebounded, but no satisfactory replacements were forthcoming. Thus, with the persistent pesticides removed, the redbacked cutworm, mint flea beetle, and mint root borers became serious problems in mint.

Comite was registered for mite control on mint in 1974, and, once again, mites could be adequately controlled. Kelthane had been the standard spider mite pesticide, but it was hard on predators.

Todd Mitcham, a new variety that exhibited more tolerance to verticillium wilt than did the older "Black Mitcham," occupied about 10 percent of the Oregon peppermint acreage by 1975. This variety made cropping feasible in areas where wilt infestation had formerly prevented recropping peppermint. While this variety is tolerant to wilt, it is still susceptible.

Increases in soil insect populations occurred throughout the 1970's, causing serious yield reductions in many areas. Redbacked cutworms caused severe losses in central Oregon in the mid-1970's. Dyfonate, which was registered for mint in 1974, was used on the soil cutworm populations.

By 1976, the mint flea beetle had become the worst insect pest on mint in the Willamette Valley and north-central Oregon, but no insecticide was registered for its control. Strawberry root weevils, widespread throughout mint production areas, continued to be a problem. Only malathion was registered on the adults, but its effect was marginal.

In 1978, the central Oregon and Willamette Valley peppermint growers evaluated an OSU Extension Service management plan. This program centered on scouting for various insect pests, but after OSU withdrew support, the program declined.

Mint flea beetle adults were managed by a summer application of Lannate. The mint root borer problem became worse in the Willamette Valley, and Lorsban and Dyfonate were both applied to combat it.

In 1981, Vydate L was also labeled for suppression of nematodes.

Orthene and Lorsban were used to control the redbacked cutworm.

The perennial weed problem had been exacerbated by non-plowing methods of disease control, and new weed control methods were needed. Propham, also known as

IPC, and a similar herbicide, CIPC, had been important for seedling annual grass control on several crops since 1950. But the mint registration lapsed in about 1970, and new registrations were sought. In 1971, Sinbar was registered for use as a fall treatment in western Oregon and was helpful in treating nonplowed mint. However, tests showed that when Sinbar and Dyfonate were applied together, they severely burned plants.

By the mid-1970's, perennial grasses, Canada thistle, and field bindweed were the primary weed problems in Oregon peppermint. Perennial weeds continued to be a problem along with new weeds:

- China lettuce
- annual ryegrass
- red root pigweed
- common groundsel
- rattail fescue
- tansy ragwort

Paraquat was granted registration in 1978. Basagran was given a state registration for control of Canada thistle and annual broadleaf weeds in 1979.

The best rotations lasted from 5 to 7 years, but when the price was high or the mint field looked vigorous, growers often allowed a field to bear too long, increasing the numbers of soil insects and diseases.

In the 1960's, when spring flaming of mature mint became a popular practice among Willamette Valley growers, peppermint rust was reasonably controlled. Fall flaming was used to control the spread of verticillium wilt. But flaming damaged older mint fields, and the mint root borer further reduced plant vigor. As a result, older, unburned fields became infected with mint rust.

1980's

To control the adult strawberry root weevil, applicators sprayed Orthene at night when the adult weevil was active. Lannate managed the adult flea beetles and was often applied twice. This practice was disruptive to mites.

Some years, predator mites have managed the mite populations. Kelthane use is limited because it kills predator mites. Some years growers apply Comite twice, the maximum allowable number of applications per year. If mite populations continue to build, growers use Kelthane, MSR, or malathion. Sometimes sulfur is also used.

Devrinol was fully registered in 1981 to control annual grasses and many broadleaf weeds, including groundsel. Buctril was granted registration in the early 1980's and was effective in broadleaf control.

Farm laborers are employed to remove weeds and are effective because they pick up weeds that have escaped herbicide control. Because of the expense and time, laborers are used to supplement herbicide treatments, not replace them.

Sinbar has remained the mainstay in weed control; Devrinol and diuron are also available. Mint growers do not have an effective grass herbicide available.

Table 22 compares pesticide usage on peppermint for 1981, 1987, and 1992.

Table 22. Pesticide Use Comparisons for Oregon Peppermint, 1981, 1987, 1992.

Herbicides	1981	1987	1992
Bentazon	51,000	1,500	60,000
Bromoxynil	—	790	14,000
Clopyralid	—	—	14,000
Dinoseb	21,000	—	—
Diuron	—	3,800	2,000
Metolachlor	—	39	—
Napropamide	1,000	4,400	2,200
Oxyfluorfen	—	6,000	2,200
Paraquat	9,000	8,700	12,000
Pendimethalin	—	250	—
Phenmedipham	—	50	—
Sethoxydim	—	—	3,300
Terbacil	44,000	28,000	52,000
Trifluralin	—	110	—
Insecticides	**1981**	**1987**	**1992**
Acephate	11,000	16,000	42,000
Carbofuran	10,000	2,000	—
Chlorpyrifos	12,000	13,000	27,000
Dicofol	3,000	3,600	660
Fonofos	39,000	24,000	39,000
Malathion	—	2,400	490
Metaldehyde	—	—	1,100
Methomyl	2,100	3,900	600
Oxamyl	5,300	4,800	38,000
Oxydemeton-methyl	—	430	520
Propargite	11,000	28,000	70,000
Fungicides	**1981**	**1987**	**1992**
Chlorothalonil	—	550	1,900
Sulfur	—	100	140,000

Typical Pest Control Year

This section outlines some of the general peppermint pest management tactics practiced by United States mint growers. Due to the wide variation in peppermint production practices, this summary will serve only as a guideline and should not be considered the only production system used.

As early as December, growers initiate their weed management programs. This often consists of using the herbicides Sinbar, Goal, Karmex, and Devrinol to provide preemergence weed suppression. These herbicides are often applied in combination with Gramoxone to burn down winter annual broadleaf weeds and grasses. Management of noxious weeds is an important part of mint production because many of the weed species adversely affect the flavor of mint oil.

Spring tillage begins in March before the mint breaks winter dormancy. Tillage has been shown to improve soil aeration, pH uniformity, and soil nutrient distribution. It also reduces populations of the mint root borer (*Fumiboyts fumalis G.*) and several annual weed species. Because tillage can spread *Verticillium* and can cause soil erosion and compaction, fewer growers practice this method of pest control. In some mint growing regions, fields are rotary corrugated for furrow irrigation. This practice is effective at incorporating soil pesticides and reducing populations of mint root borer.

In the early spring when temperatures are mild, growers apply Buctril and Sinbar separately to manage seedling broadleaf weeds. Sinbar is active on some grasses as well. When temperatures are warmer, Basagran is used instead of Buctril to manage broadleaf weeds because it is safer on the mint. The herbicide Stinger is applied in May to suppress Canada thistle and salsify populations.

During the spring, fields are sampled for populations of these pests:

- soil cutworms
- symphylans
- root weevils
- mint flea beetles
- wireworms
- plant parasitic nematodes

If populations of these pests are above the economic treatment threshold, Lorsban, Orthene, and Dyfonate are applied to manage soil cutworms, and Dyfonate is used to suppress wireworms. Dyfonate and Lorsban are used to manage populations of garden symphylans. Wireworms and symphylans can be especially damaging to new stands of mint, so if high populations are detected, Dyfonate or Lorsban is incorporated prior to planting. Fields infested with damaging levels of mint flea beetle larvae can be treated with insect attacking nematodes. Adult flea beetles may be treated with Lannate or Malathion after they have emerged from the soil. Root weevil larvae can also be treated with insect attacking nematodes, although this method has not been demonstrated to work effectively by itself. Evening applications of Orthene for adult root weevils have been effective when applications are timed properly. High populations of plant parasitic nematodes are treated in the early spring with Vydate. Impregnating Vydate on fertilizer or watering it in immediately with overhead sprinkler irrigation is necessary to avoid disrupting beneficial insect and mite predators.

In Oregon's Willamette Valley, fields are propane flamed in early spring to control mint rust. A thorough job of flaming is also effective at reducing populations of spider mites and small weeds. Spring flaming is not practiced in other mint growing regions because of shorter growing seasons and harsher winters. Sulfur may also be applied to manage powdery mildew, a constant problem on mint in several growing districts.

Mid- to late-June, fields are closely inspected for damaging populations of these pests:

- foliar cutworms
- loopers
- aphids
- spider mites

All four of these pests are frequently maintained below economic thresholds by beneficial natural enemies. If they are found to be above these thresholds, growers apply Orthene to reduce populations of cutworms, loopers, and aphids. Comite is used to suppress spider mites. Both Orthene and Comite are important components of integrated pest management programs because they are gentle on natural enemies. During this time, fields are hand hoed to eliminate weeds that have escaped herbicide treatment. This serves to reduce the seed bank and slow the selection of herbicide resistant weeds.

Single cut mint is harvested from late July into September. Double cut mint is harvested in early June and again in late August or September. Fields are sampled in late August and early September for mint root borers. Populations of root borers exceeding the economic threshold are treated with Lorsban or insect attacking nematodes.

Following harvest, growers make a final decision whether to maintain their fields in mint or to rotate in another crop. This decision is usually based on the buildup of insects, weeds, and diseases, especially verticillium wilt. Management of verticillium wilt consists of planting clean rootstock and wilt tolerant varieties. In several mint growing regions, wilt spread is also managed by fall propane flaming.

Fields that will be maintained in mint are often treated with Sinbar, Buctril, or Basagran to reduce populations of seedling weeds. Stinger is often applied in the fall to manage Canada thistle and dandelions.

1992 pesticide use for the Willamette Valley is outlined in Table 23. Eastern Oregon use is listed in Table 24.

Table 23. Pesticides Use Estimates for Willamette Valley, Oregon Peppermint, 1992. 27,000 acres.

Common Name	Trade Name	Formulated Rate of Application	Method of Application	Acres Treated	Pounds Used a.i.
HERBICIDES					
>>>>>>>groundsel, pigweed, thistle					
Bentazon	Basagran 4E	1.0 - 2.0 qt/acre	broadcast, foliar	13,000 (48%)	13,000
>>>>>>>groundsel, pigweed					
Bromoxynil	Buctril 2E	1.0 - 1.5 pt/acre	broadcast, foliar	25,000 (93%)	7,000
>>>>>>>groundsel					
Napropamide	Devrinol 4E	4.0 qt/acre	broadcast, soil	780 (3%)	1,800
>>>>>>>groundsel, bluegrass					
Diuron	Diuron 80W	2.0 - 3.0 lb/acre	broadcast, soil		
	Direx 4L	1.6 - 2.4 qt/acre		1,200 (4%)	1,500
>>>>>>>dandelion, groundsel					
Oxyfluorfen	Goal 1.6E	1.0 pt/acre	broadcast, soil	7,800 (29%)	1,600
>>>>>>>dandelion, groundsel, pigweed, ryegrass					
Paraquat	Gramoxone 2.5E	1.0 - 2.0 pt/acre	broadcast, foliar	15,000 (57%)	7,700
>>>>>>>millet, quackgrass, ryegrass					
Sethoxydim	Poast 1.5E	1.0 qt/acre	spot treatment	6,200 (23%)	2,200
>>>>>>>groundsel, pigweed, quackgrass, ryegrass					
Terbacil	Sinbar 80W	1.0 - 2.0 lb/acre	broadcast, soil	17,000 (63%)	21,000
>>>>>>>dandelion, Canada thistle					
Clopyralid	Stinger 3E	0.33 - 0.5 pt/acre	broadcast, foliar	16,000 (60%)	13,000
INSECTICIDES					
>>>>>>>root borer					
Chlorpyrifos	Lorsban 4E	2.0 qt/acre	broadcast, soil	11,000 (39%)	21,000
Parasitic nematodes	BioVector	3.0 oz/acre		540 (4%)	——
>>>>>>>spider mite					
Dicofol	Kelthane MF	2.0 - 3.0 qt/acre	broadcast, foliar	1,700 (6%)	610
Propargite	Comite 6.5E	1.0 - 1.5 qt/acre	broadcast, foliar	7,500 (28%)	14,000
>>>>>>>symphylids					
Fonofos	Dyfonate 4L	2.0 qt/acre	broadcast, soil		
	Dyfonate 10G	20 lb/acre		19,000 (71%)	39,000
>>>>>>>cutworms					
Methomyl	Lannate 90W	1.0 lb/acre	broadcast, foliar	390 (1%)	350
>>>>>>>flea beetles					
Malathion	Malathion 4	1.0 qt/acre	broadcast, foliar	3,900 (1%)	390
>>>>>>>cutworms, root weevils					
Acephate	Orthene 75W	1.33 lb/acre	broadcast, soil	25,000 (94%)	25,000
>>>>>>>slugs					
Metaldehyde	Slug Bait 4%	20 lb/acre	field perimeter	1,300 (5%)	1,100
>>>>>>>nematodes					
Oxymyl	Vydate 2L	4.0 - 5.0 pt/acre	broadcast, soil	16,000 (60%)	21,000
FUNGICIDES					
>>>>>>>rust					
Chlorothalonil	Bravo	1.5 qt/acre	broadcast, foliar	1,300 (5%)	1,900
>>>>>>>powdery mildew, spider mite					
Sulfur	Thiolux 80 DF	3.0 lb/acre	broadcast, foliar	3,500 (13%)	8,400

Table 24. **Pesticides Use Estimates for Eastern Oregon Peppermint and Spearmint, 1992. 23,600 acres.**

Common Name	Trade Name	Formulated Rate of Application	Method of Application	Acres Treated	Pounds Used a.i.
HERBICIDES					
>>>>>>>groundsel, kochia, lambsquarter, pigweed					
Bentazon	Basagran 4E	1.0 - 2.0 qt/acre	1st application	23,000 (100%)	32,000
Bentazon	Basagran 4E	1.0 - 2.0 qt/acre	2nd application	18,000 (75%)	25,000
Bromoxynil	Buctril 2E	1.0 - 1.5 pt/acre	1st application	23,000 (100%)	3,100
Bromoxynil	Buctril 2E	1.0 - 1.5 pt/acre	2nd application	23,000 (100%)	3,100
Bromoxynil	Buctril 2E	1.0 - 1.5 pt/acre	3rd application	4,700 (20%)	620
>>>>>>>kochia, lambsquarter					
Napropamide	Devrinol 4E	4.0 qt/acre	broadcast, soil	420 (2%)	420
>>>>>>>lambsquarter					
Diuron	Karmex 80W	2.0 - 3.0 lb/acre	broadcast, soil	700 (3%)	480
>>>>>>>groundsel					
Oxyfluorfen	Goal 1.6E	1.0 pt/acre	broadcast, soil	1,300 (27%)	900
Paraquat	Gramoxone 2.5E	1.0 - 2.0 pt/acre	broadcast, foliar	8,100 (35%)	4,200
>>>>>>>foxtail, quackgrass					
Sethoxydim	Poast 1.5E	1.0 qt/acre	spot treatment	3,400 (14%)	1,100
>>>>>>>groundsel, kochia, lambsquarter, pigweed, quackgrass					
Terbacil	Sinbar 80W	1.0 - 2.0 lb/acre	1st application	23,000 (100%)	17,000
Terbacil	Sinbar 80W	1.0 - 2.0 lb/acre	2nd application	19,000 (80%)	14,000
>>>>>>>dandelion, Canada thistle, salsify, pigweed, groundsel					
Clopyralid	Stinger 3E	0.33 -0.5 pt/acre	broadcast, foliar	4,200 (18%)	800
INSECTICIDES					
>>>>>>>cutworms					
Chlorpyrifos	Lorsban 4E	2.0 qt/acre	broadcast, soil	4,100 (17%)	6,000
>>>>>>>spider mite					
Dicofol	Kelthane MF	2.0 - 3.0 qt/acre	broadcast, foliar	140 (1%)	50
Propargite	Comite 6.5E	1.0 - 1.5 qt/acre	1st application	19,000 (80%)	38,000
Propargite	Comite 6.5E	1.0 - 1.5 qt/acre	2nd application	9,000 (38%)	18,000
>>>>>>>spider mite, aphids					
Malathion	Malathion 4	1.0 qt/acre	broadcast, foliar	980 (4%)	490
Oxydemeton-methyl	Metasystox-R		broadcast, foliar	980 (4%)	520
>>>>>>>cutworms					
Methomyl	Lannate 1.8E	2.0 qt/acre	broadcast, foliar	280 (1%)	250
>>>>>>>cutworms, root weevils					
Acephate	Orthene 75W	1.33 lb/acre	broadcast, soil	10,000 (44%)	17,000
>>>>>>>nematodes					
Oxymyl	Vydate 2L	4.0 - 5.0 pt/acre	broadcast, soil	14,000 (59%)	17,000
FUNGICIDES					
>>>>>>>powdery mildew, spider mite					
Sulfur	Thiolux 80 DF	3.0 lb/acre	broadcast, foliar	33,000 (138%)	100,000

Sugar Beets

Production

Growers knew for a long time that sugar beets contained sugar, but it was not until the late 19th century that beets successfully competed with sugarcane for sugar production. During that century, research into beet selection, cultivation, and improved sugar extraction methods ushered in a new era of sugar production. Germany was the heart of the sugar beet industry, but in the 1800's, the United States began to produce a domestic sugar supply. After several failures, the first successful United States commercial beet sugar production began in 1879 at Alvarado, California.

Sugar beets in Oregon had three false starts. The first was in 1898 in La Grande (an area particularly well suited for sugar beet production), and a factory was erected there. Beet production was short lived: beets were grown only from 1898 to 1904. Sugar beets were grown in the Nyssa area from 1906 to 1910. From 1916 to 1919, farmers grew sugar beets at Grants Pass, but they were reluctant to continue growing beets, and the processing plant was moved to Toppenish, Washington.

The Willamette Valley was handicapped by soil that was too clay-like for sugar beet production and rains that were likely to occur at harvest. As a consequence, no beets for sugar production were grown in the valley, and the industry was not established in Oregon until the mid-1930's. Sugar beets were reestablished in the Nyssa area of the Treasure Valley in 1937 and have been in production ever since. Sugar beets were planted in the Klamath Basin in the 1940's, but frost and the lack of economic weed control doomed the effort. In the early 1980's, Spreckels Sugar Company again tried sugar beet production in the Klamath Basin, but the closest processing plants were located in California, and, while beets could be grown successfully, transportation costs to the processing plants made economic sugar beet production impossible. Holly Sugar Corporation approached the University Experiment Stations at Tulelake and Klamath Falls in the late 1980's to see if anything could be done to make economic sugar beet production in the basin a reality. After several years of testing varieties, varying planting dates, and conducting fertility studies, researchers developed successful cultural practices for the basin. Commercial production began in 1990, and sugar beet acreage has nearly doubled each year. Both sugar beet companies have been contracting acreage each year. Sugar beets still must be transported to plants at Woodland and Hamilton City,

Figure 24. Annual Acres of Oregon Sugar Beets Harvested, 1898-1992.

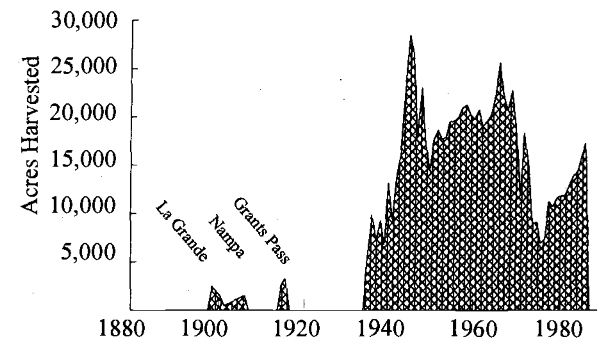


Figure 25. Annual Production of Oregon Sugar Beets Harvested, 1937-1992.

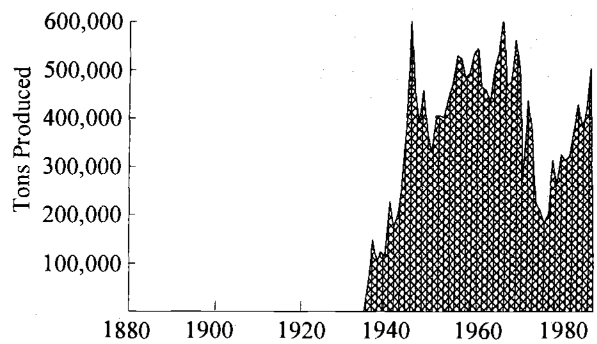
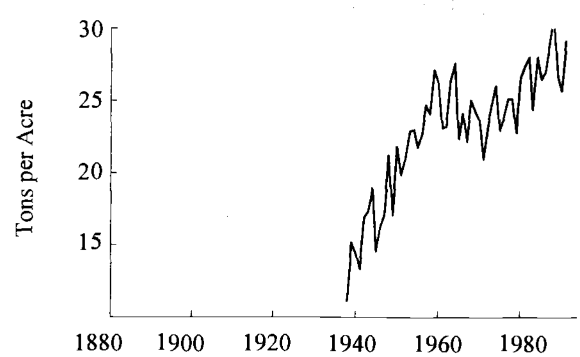


Figure 26. Annual Average Yield of Oregon Sugar Beets Harvested, 1937-1992.



U.S. Sugar Statistical Compendium, USDA ERS SB 830 (1950-1990)
Arrington, L.J., 1966. Beet Sugar in the West, pp. 186-191.

California, but the excellent yields of high quality sugar beets grown in the basin have made them an exciting new cash crop in a region traditionally limited to potatoes, alfalfa, and grain. Plantings were established in the Hermiston area around 1950, and production continued until 1978, when falling prices plagued the industry. In 1992, a few new acres of sugar beets were planted again in this region, with hopes for increased acres in the future. Beets were shipped by truck to processing plants.

Beet seed grew in multigerm cluster and, as a result, germinated in clumps. In order for the beets to size correctly as they matured, the clumps had to be hand thinned. During World War II, many Japanese-Americans who were in relocation camps worked in the sugar beet fields, weeding and thinning beets. They were paid the prevailing wage and provided adequate labor for beet cultivation.

During the 1940's, the seed was segmentized, that is, broken apart mechanically. Although about half of the beet seed was lost in the process, it allowed the grower to plant single seeds and avoid the added cost of hand thinning beet clusters. Monogerm (single) seed was developed in the 1950's and, a decade later, was used in all production areas.

The Sugar Act Agreement that governed the base price of sugar was not renewed in 1974. As a result, sugar prices soared and then fell rapidly. It was reinstated in 1980, but with no legislation, production fell during the 5-year interval. Figures 24 and 25 show a large drop in acreage and production from 1975 to 1980. In this time period, yields were not so impacted (Figure 26). The U&I Sugar Company, which processed sugar beets in the Columbia Basin region of Washington and Oregon from the 1950's to 1978, was unable to participate in the recovery and went out of business. Legislation had mixed results for the sugar industry, helping some, hindering others. However, plant diseases and fluctuating prices damaged the industry.

Historical Pesticide Use in Sugar Beets

Curly top virus (BCTV), transmitted by the beet leafhopper, caused the greatest threat to sugar beets. This disease was epidemic in the western states growing region and created an early history of alternating crop successes and failures over a period of nearly 40 years. In the 1920's and 1930's, it nearly eliminated the industry in the Rocky Mountain States.

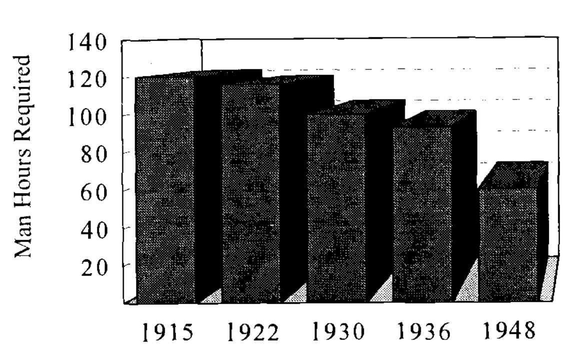
At the turn of the century, when sugar beets were introduced into Oregon, the Agricultural Experiment Station was looking for good sugar beet varieties and growing regions. In the Treasure Valley, sugar beets were shipped across the border to Idaho for processing. In 1906, a new plant was constructed at Nampa, Idaho, which received beets from the Treasure Valley in Oregon, as well as Idaho. However, curly top was so destructive that production ceased. In 1910, the plant was closed, and in 1916, it was moved to Utah.

During the First World War, growers expanded into less productive western sagebrush lands as the demand for wheat rose. At the end of the war, when wheat prices fell, this land was abandoned because farming in these areas was unprofitable. Weeds such as Russian thistle, mustards, and salt brush established in these abandoned lands and provided host vegetation for the beet leafhopper. This insect was a vector of BCTV and transmitted the disease to the sugar beet fields, causing many epidemics. Many sugar beet processing plants (like the one at Parma, Idaho) were closed or moved because production dropped precipitously.

In 1930, researchers developed a new sugar beet. Named US1, it was the first of a series of beets with some resistance to curly top. This stabilized the industry; curly top no longer forced processing plants to move or close. Cercospora leaf spot was another serious disease of sugar beets, and in 1938, plant breeders released a leaf spot resistant variety. Since then, some resistance to curly top and Cercospora leaf spot has been bred into sugar beets.

When Oregon production began in the mid-1930's, chemical weed control was seldom practiced because the few herbicides available (such as sodium chlorate and sodium bisulfide) were used only as spot treatments for noxious weed control. Instead, growers cultivated as many times a year as was necessary to control weeds between the beet rows. Hired labor crews were used to thin beets and hoe weeds within the rows. Labor costs were dramatically reduced in the 1940's and 1950's when segmentized seed became available (Figure 27), and herbicides were widely used.

Figure 27. Historical Trends in Labor Requirements to Produce a Sugar Beet Crop.



Beet-Sugar Economics, R.H. Cottrell, 1952.

Prior to the availability of segmentized seed and herbicides, disease control depended on plant resistance to curly top and on proper watering to prevent damping-off. Other diseases—downy mildew, various root rots, powdery mildew, leaf spot diseases—were poorly controlled. Leaf spot was treated with coppers or Bordeaux mixture. Some nematode control was obtained with Dow Fume, a formulation of ethylene dibromide, or with Shell DD, a dichloropropane and dichloropropene mixture.

Prior to and during the Second World War, some pyrethrums were used to combat the beet webworm, and nicotine sulfate helped control aphids. However, both of these insecticides were in short supply because of the war.

After World War II, many new pesticides were developed. DDT use in sugar beets began in 1945 and quickly expanded in the years following for control of Lygus bugs, flea beetles, and other foliar insect pests. Toxaphene, lindane, and parathion became available about the same time as DDT. Toxaphene replaced pyrethrums for grasshopper and beet webworm control. The most destructive pest, the beet leafhopper, was controlled by a comprehensive program that included:

- removal of curly top virus weed hosts
- destruction of other leafhopper host plants
- development of resistant varieties
- usage of insecticides

1950's & 60's

Growers began to treat seed with insecticides and fungicides in 1950. Lindane and PCNB, with green dye added to mark the treated seeds, were the first commercial products applied to beet seed.

Prior to the use of herbicides and commercial fertilizers, seed beds were prepared with manure or cover crops that made an excellent environment for the germination of both crop and weed seeds. The first cultivation was normally done preemergence to kill weeds so small that they could not be seen readily . Sometimes two or three more cultivations were required before beet plants were thinned. After thinning, the beets were cultivated three or four more times. Other weeds were controlled by hoeing and hand weeding. Once plants were established with sufficient foliage, weeds were shaded out. Sometimes, in very weedy fields, flaming was used to control weeds, prior to beet emergence. However, this tended to damage beets and reduce yields.

Although some diesel oil and salts were applied as contact herbicides, it was not until 1952 that serious use of herbicides was prevalent. The first herbicides used were the following:

- IPC
- endothall
- dalapon
- TCA (occasional use)

In about 1960, Eptam was registered as a preemergence herbicide in sugar beets. After Eptam was registered, other chemical registrations followed:

- Avadex
- Pyramin
- Tillam
- Ro-Neet
- Betanal

The years from 1963 to 1969 were transition years as chemical weed control practices replaced nonchemical cultural weed control. Most failures of chemical weed control were caused by improper timing of application or poor herbicide application technique.

1970's & 80's

Seedling diseases were not well controlled by crop rotation and proper water management. PCNB and Captan became the standard seed treatments. The key to Cercospora leaf spot control, like other diseases, was crop rotation, which allowed the spores and mycelium on infected plant debris to die. Protective fungicide applications were used extensively with good results. Repeated applications of fixed coppers reduced the incidence of disease and increased the yield and sugar percentage. By the beginning of the 1970's, Mertect and Benlate supplemented these fungicides. The best Cercospora leaf spot control was achieved by planting resistant varieties.

Early in the season, downy mildew infestations lowered beet yields more than later infestations. Fungicide sprays and dusts had never achieved satisfactory control, but resistant varieties helped decrease downy mildew. Destroying volunteer beets and other host plants helped eliminate the sources of inoculum.

Dicofol was commonly used to control mites. Research from 1962 through 1969 found that MSR adequately controlled the green peach aphid, and yields increased substantially.

Ro-Neet, Treflan, and Eptam were used for weed control all through the 1960's, and in 1970, Betanal was used to supplement these herbicides. Lay-by treatment, where a pesticide is applied on the crop row beside a fairly well developed plant, also helped control pests.

In 1974, powdery mildew first appeared in the Treasure Valley. Within 3 years, growers were using two applications of sulfur to control the mildew. Bayleton, a new fungicide available in 1976, helped control powdery mildew along with applications of sulfur. However, in about 1987, a new sugar beet variety, which was fairly resistant to powdery mildew, replaced the standard variety. This new variety could be grown without the large scale use of sulfur.

In 1980, Betamix replaced Betanal. At that time, growers commonly applied 1 1/2 to 2 pints per acre, but in freezing temperatures, they could incur a major stand loss. Today, growers apply lower rates of Betamix over several applications.

Root maggots were discovered in the Treasure Valley in about 1982 and two years later had developed into a major infestation. Granular Thimet was applied at the first cultivation to control maggots. However, maggots were often present prior to coverage, and, as a result, Furadan 15G was applied in the furrow at planting. Since it was necessary to control wireworms, white grubs, and crown borers, Counter 15G soon replaced Furadan at planting. Application equipment was adapted for pinpoint placement of seed and Counter to achieve maximum control.

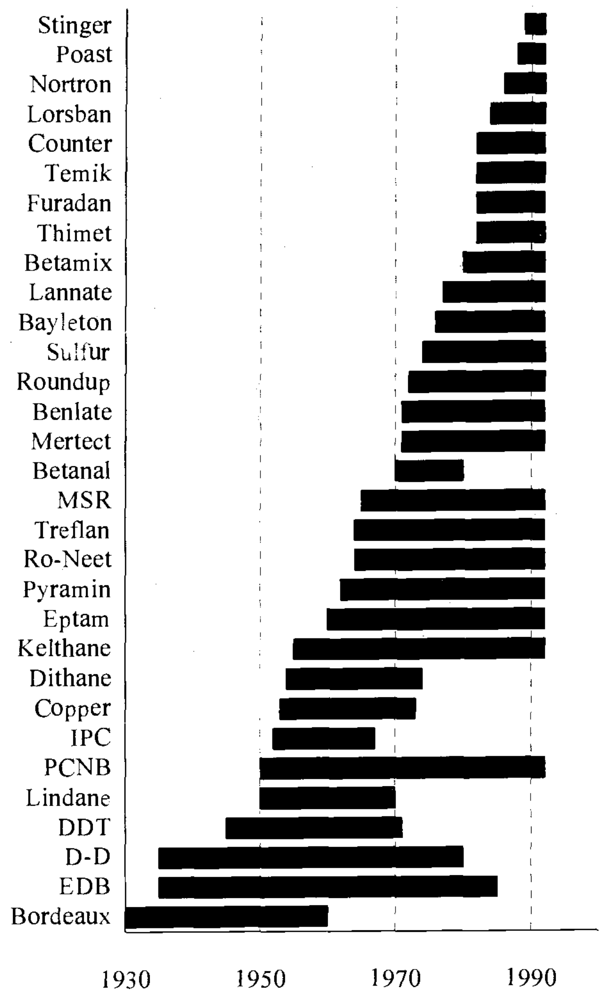
Table 25. Pesticide Use Comparisons for Oregon Sugar Beets, 1981, 1987, 1992.

Herbicides	1981	1987	1992
Clopyralid	——	——	8,400
Cycloate	——	36,000	56,000
Desmedipham	——	3,300	800
Endothall	——	1,500	——
EPTC	——	——	8,600
Glyphosate	——	——	5,700
Ethofumesate	——	6,300	5,800
Phenmedipham	——	2,300	800
Sethoxydim	——	——	2,700
Trifluralin	——	6,000	7,800

Insecticides	1981	1987	1992
Aldicarb	——	——	4,300
Bacillus thuringiensis	——	——	570
Carbaryl	——	——	13,000
Carbofuran	——	——	3,800
Chlorpyrifos	——	——	3,800
Fonofos	——	1,600	——
Naled	——	——	950
Oxydemeton-methyl	——	——	710
Phorate	——	5,800	——
Terbufos	——	4,900	210,000

Fungicides	1981	1987	1992
Metalaxyl	——	——	120
Sulfur	——	39,000	460,000
Triadimefon	——	3,200	——

Figure 28. Prominent Pesticides Used on Sugar Beets with General Period of Use.



Temik 15G was also used. Although its initial application was expensive (growers shanked it in and watered to activate it), it achieved long-term control of leaf miners and leafhoppers.

Sugar beet plant varieties resistant to curly top still need to be protected from inoculum. In drought years (such as in 1992), large numbers of beet leafhoppers migrate into beet fields from the desert regions. When the leafhopper pierces the beet, it injects a toxin, then sucks the plant juices, taking with it the virus, if present. In about 24 hours, the virus has moved from the digestive system of the insect into the toxic digestive fluid that is injected into the plant. Therefore, it is important to eliminate the leaf hopper quickly before the disease is spread throughout a field. Scouting for leafhoppers, crown borers, and other insects, weeds, and diseases is done continuously by company agricultural advisors.

Crown borers are another pest recently introduced to sugar beets in the Treasure Valley. Growers monitor crown borer flights by pheromone trapping, but untreated fields are always infested with crown borers, which could have been controlled by applications of Counter insecticide at planting. Crown borers in untreated fields can be controlled by Lorsban 4E applications to treat aphid infestations. Good efficacy has been observed with this treatment. It has been noticed that the presence of wireworms has been increasing in the past 5 years as DDT residues have declined.

Many pesticides have been used for sugar beet production in Oregon. Those most commonly used are found in Figure 28. Pesticide use comparisons from 1987 and 1992 are tabulated in Table 25.

Current Pest Control Practices

Treasure Valley

In the fall and winter, growers prepare seedbeds for planting, and they often apply Roundup to kill any weeds present before planting. The bulk of the planting is done between March 25 and April 10, although in 1992, which was an unseasonably warm year, most of the plantings were in by late March. Ro-Neet and Nortron are preplant applications that are incorporated into the soil. If Russian thistle or kochia are a problem, Nortron is banded preplant or applied later with Betamix. At planting time, growers apply Counter in a 2-inch band; it is incorporated into the top half inch of the soil, just above the seed, for root maggot and crown borer control, primarily.

When the weeds germinate and are still quite small, 10 to 12 ounces of Betamix are applied as a broadcast treatment. Three more Betamix treatments are banded, in a 7-inch band width, over a 5- to 7-day interval, depending on when weeds germinate. If Canada thistle or cocklebur is a problem, Stinger is applied along with the second or third Betamix treatment. This combination also enhances nightshade control. If the temperature approaches 75°F, Betamix is applied late in the day (when temperatures are decreasing) to avoid phytotoxicity. With this program, no other chemical weeding is necessary. Normally, three cultivations follow chemical treatments; in the past, four or five were necessary. Ro-Neet is effective on redroot pigweed and lambsquarter; Poast is used for grass control. Broadleaves are controlled by applying Eptam, Treflan, Betamix, and Stinger. The beets, planted at 7-inch spacing, soon develop a large canopy. The thicker stands improve weed control and beet growth because this spacing provides optimum density for beet production. Beets are uniform in size and use nearly all the nitrogen supplied to the soil.

Normally, troublesome insects begin to appear in May, but the 1992 early warm weather brought on insect problems sooner. Integrated Pest Management (IPM) is still in its infancy in sugar beet production. Moreover, each growing region has a different set of problems, and new pests occasionally appear, making pest management more complex.

Insect pests begin appearing in the following general order, but some overlap is common. Once soil temperatures reach about 55°F, nematodes become quite active. Next come these pests:

- cutworms
- root maggots
- crown borers
- wireworms
- white grubs

They are controlled by soil treatments at planting. Leaf miners, leafhoppers, and green peach aphids are also controlled by Temik if it is applied early. Lorsban is used for all worm control.

Other pests include symphylans, which appear later. Black bean aphids are also an occasional concern, though they were not a problem in 1992. Loopers and armyworms can infest sugar beets.

Pesticide use on sugar beets in 1992 is shown in Table 26 in a format that identifies the period of application and the pest treated. Other data include the following:

- pesticide common name
- trade name
- rate of use (formulated rate)
- method of application (seed treatment, baits, broadcast, banded, and foliar)
- acres treated
- total pounds used

Klamath Basin

Sugar beet success in the Klamath Basin is determined mainly by the absence of pests that destroy yield and quality. Loss of productive acreage in California to pest damage and development has helped fuel the economic success of sugar beet production in the Klamath Basin.

Weed control is the number one concern in establishing a good stand of beets. Insect and disease problems have not been a major problem. Some problems exist with flea beetles, cutworms, and powdery mildew, but they are controlled the same as those in the Treasure Valley. The following pests are not a problem in the Klamath Basin:

- rhizoctonia
- sugar beet cyst nematode
- sugar beet root maggot
- curly top

Planting of resistant varieties and proper sanitary cultural techniques are the keys to the continued success of beet farming in this region.

Table 26. Pesticides Use Estimates for Oregon Sugar Beets, 1992. 24,000 acres.

Common Name	Trade Name	Formulated Rate of Application	Method of Application	Acres Treated	Pounds Used a.i.
SEED TREATMENT					
>>>>>>>Diseases: root rots, damping-off					
Metalaxyl	Apron	4.0 oz/100 lb seed		—	120
PLANT BED PREPARATION					
>>>>>>>Weeds: germinating weeds					
Glyphosate	Roundup	1.0 qt/acre	foliar	5700 (30%)	5700
PREPLANT					
>>>>>>>Weeds: redroot pigweed, lambsquarter					
Cycloate	Ro-Neet 6E	3.0 qt/acre	broadcast, incorporate	12000 (65%)	56000
>>>>>>>Weeds: broadleaf weeds					
EPTC	Eptam 7	3.5 pt/acre	broadcast, incorporate	2900 (15%)	8600
Trifluralin	Treflan	1.0 - 1.5 pt/acre	broadcast, incorporate	10000 (55%)	7800
>>>>>>>Weeds: Russian thistle, kochia					
Ethofumesate	Nortron SC	3.0 qt/acre	banded	3800 (20%)	2900
PLANTING					
>>>>>>>Insects: root maggots, wireworms, white grubs, crown borers					
Terbufos	Counter 15G	2.5 - 5.0 lb/1000 ft. row	in furrow	16000 (85%)	210000
Carbofuran	Furadan 15G	30 lb/acre	in furrow	1900 (10%)	3800
>>>>>>>Insects: root maggots, wireworms, white grubs, crown borers, leaf miners, leafhoppers					
Aldicarb	Temik 15G	7 - 14 lb/acre	shanked	2900 (15%)	4300
POSTPLANT TREATMENTS four applications every five to seven days					
>>>>>>>Weeds: germinating broadleaf weeds					
Desmedipham + Phenmedipham	Betamix	10 -12 ounces	broadcast	13000 (70%)	1600
POSTPLANT TREATMENTS					
>>>>>>>Weeds: Canada thistle, cocklebur, nightshade, sow thistle					
Clopyralid	Stinger	0.5 - 0.67 pt/acre	broadcast	3800 (20%)	8400
>>>>>>>Weeds: Russian thistle, kochia					
Ethofumesate	Nortron SC	3.0 qt/acre	banded	3800 (20%)	2900
>>>>>>>Weeds: grasses					
Sethoxydim	Poast	1.5 - 2.5 pt/acre	foliar	6700 (35%)	2700
SPRING					
>>>>>>>Diseases: powdery mildew					
Sulfur	Dry Sulphur	30 lb/acre	foliar	15000 (80%)	460000
>>>>>>>Insects: leafhoppers					
Naled	Dibrom 8	1.0 pt/acre	foliar	950 (5%)	950
Oxydemeton-methyl	Metasystox-R	1.0 - 3.0 pt/acre	foliar	950 (5%)	710
>>>>>>>Insects: cutworms, loopers					
Carbaryl	Sevin XLR	2.0 qt/acre	foliar	6700 (35%)	13000
Bacillus thuringiensis	Dipel	1.0 - 2.0 qt/acre	foliar	380 (2%)	570
>>>>>>>Insects: crown borers					
Chlorpyrifos	Lorsban 4E	1.0 qt/acre	foliar	3800 (20%)	3800

Christmas Tree Plantations

Production

Martin Luther is thought to have been the first person to have a decorated evergreen tree in his home at Christmas. Christmas trees first appeared in America in the early 1800's and were actually called "Christian Trees." First marketed successfully in Los Angeles, California in 1907, the Oregon Douglas-fir trees were not sheered or graded. The usual price paid to the owner was a penny a tree. Shipping problems were common and adverse weather conditions could cause delays. This occurred in the early 1930's when winter storms paralyzed traffic. Crops were also destroyed by adverse weather conditions as happened in 1955, when a severe late freeze destroyed much of the Oregon crop.

Christmas tree plantations developed early this century out of the conservation movement. The sight of unsold trees at the end of the season probably started the rumor that the nation's forests were being denuded, and cutting evergreens for Christmas trees became an important issue during the presidency of Theodore Roosevelt, a conservationist who forbade their use in the White House. In reality, the trees were harvested from natural stands on cutover timber lands, and Gifford Pinchot, an advisor to the President, stated that supervised harvesting of Christmas trees in the national forests was beneficial. Regardless, the cutting of Christmas tree was looked upon as one of the major contributing factors to the degradation of the national forests. Out of this situation, the idea of growing Christmas trees as a farm crop was born.

The first Christmas tree farm was established in Pennsylvania in 1918. Production expanded to neighboring states throughout the 1920's and 1930's. Because of production and marketing problems, tree producers' organizations were founded, starting with the Pennsylvania Christmas Tree Growers organization in 1942. After several other states had formed groups, Washington and Oregon growers formed the Northwest Christmas Tree Association on September 17, 1953 with 67 charter members. A year later, the National Christmas Tree Growers Association, composed of members from the state organizations, was formed.

In the 1940's, growers in Washington and Oregon began to prune Douglas-fir. This improved the salability of the trees and was the beginning of shaping trees. Automated handling of trees at the source point began in the 1950's with the introduction of conveyor belts and balers. Pruning, fertilizing, and applying pesticides raised the quality of the Oregon and Washington Douglas-fir. Flocking, introduced in 1958, was especially successful with Scotch pine, which in 1964 was the best selling Christmas tree nationally (Douglas-fir was second). Annually, 7 to 8 million trees are harvested, and about 15 percent of the growers produce 75 percent of the trees.

Historical Pesticide Use on Christmas Trees

In the beginning years of Oregon Christmas tree farming, pesticides were not used. Weed control was achieved by cultural techniques such as mowing or grubbing. The main problem with weeds, especially grasses, was that they competed for water during the dry summer months. Vegetation also provided cover for rodents that girdled the trees, providing a breeding ground for destructive insects. Mowing controlled most weeds and, with proper tree spacing, did not mechanically damage the trees. However, mowing to improve moisture conservation was only about 25 percent as effective as complete weed eradication. Cultivation was more expensive than mowing and seriously damaged feeder roots. This tillage practice also resulted in a significant moisture loss. It was a common practice to cut a furrow with a double moldboard plow and plant the trees in the furrow. Although many trees could be planted, it was a poor cultural practice and was generally abandoned as herbicides became available. Proper chemical control offered the most economical weed control without tree injury or moisture loss.

Weed control in Christmas trees was limited at first to ammate and sodium arsenite, but these were supplanted by 2,4-D and 2,4,5-T. Sodium arsenite was poisonous and ammate was both corrosive and expensive. They were applied to control brush and hardwood trees. By 1960, five new herbicides were in common use in Christmas trees. Aminotriazole was applied to the foliage and helped contain poison oak. Fenuron, a soil active chemical, was applied as a pellet to control deep rooted perennials. Dalapon, applied occasionally, controlled grasses. Simazine and atrazine were the most commonly applied herbicides and controlled grasses.

A weed-free planting strip was made by using simazine, dalapon, or Amitrol-T. In Oregon, atrazine replaced simazine because of the highly organic soils and high precipitation. Herbicide applications kill the grass that is growing in the areas where the trees will be planted. Trees are then planted in the dead grass, a type of mulch that serves as a moisture conservation aid by shading the ground from the direct heat of the sun. This mulch serves to make the trees more tolerant to drought, the biggest cause of tree mortality. Heavy grass root cover occupies the soil equally at the 3-foot depth. Such a living mulch will withdraw water to that depth, but when the grass is dead, adequate moisture will remain throughout the summer. Young trees, clipped off by rodents and deer, recover and grow in farms where the weeds are controlled.

On land where brambles were a problem, 2,4,5-T and 2,4-D were applied. After the trees were established, the spaces between the rows were mowed frequently. However, by the end of the 1960's, more growers relied on chemical control of weeds during the year following planting.

The Douglas-fir needle midge was first recognized as a Pacific Northwest Christmas tree pest in 1954, and by the 1960's, it caused needles to become distorted. Thiodan has been the standard treatment for this fly.

Lophodermium needle cast disease infected Scotch pine in the 1960's, and trees defoliated by this disease could not be sold. Maneb was used to help control the disease but was later replace by Dithane M-45 (mancozeb).

In 1925, Swiss needle cast, a disease native to the Pacific Northwest, was first identified in Switzerland on Doulas-fir shipped from this area. In 1976, forest pathologists received reports of needle cast damage in Christmas trees. Densely sheared crowns and close tree spacing increased susceptibility. The resulting restricted air flow kept foliage moist, a condition favorable to infection. Swiss needle cast discolored and defoliated infected trees. Christmas trees that had been infected for two consecutive years usually had sparse foliage and were destroyed or sold at a loss. The epidemic continued into the 1980's. At that time, Bravo was registered to control this disease, and as a result, the inoculum level decreased sharply. Although no longer a threatening disease, growers feared that if chemical control measures were halted, the disease would resurge to large proportions in a few years.

By 1980, it was well recognized that weed control in Christmas tree plantations was necessary if high quality trees were to be produced with a minimum of cost. Weed control measures do the following:

- Improve survival and growth of trees
- Result in better formed trees
- Provide better working conditions
- Reduce insect and disease potential
- Reduce the potential for animal damage
- Reduce fire hazard in summer and fall
- Produce more attractive trees

Studies in Oregon have shown that extensive weed control measures can reduce significantly the time required to grow an average tree.

By 1980, the most commonly applied soil herbicides were atrazine, Kerb, and Velpar. In Oregon, simazine was used to a lesser extent. These were the backbone of the vegetation management program and were applied in the tree row. There were several foliar applied herbicides; Amitrol-T was most commonly used, but Paraquat and 2,4-D were also applied. Use of 2,4,5-T was suspended in 1978. Roundup, used on Christmas tree plantations since 1976, was the most useful herbicide since atrazine. Tree growers applied Surflan, in addition to atrazine, to control more resistant grasses. In the mid-1980's, growers began using a mixture of 2,4-D and Velpar. During that time, Oregon growers used Asulox to control bracken fern and horsetail rush.

An important change in label interpretation in the mid-1980's reduced the number of pesticides available for use on Christmas tree plantations. Up to that time, "Christmas tree crop" was broad enough to include ornamental trees—fir, pine, and various other nonspecific names. However, registration changes demanded that all pesticides used for Christmas tree plantation crops must be registered specifically for that use.

Pest Control Management Practices

Christmas trees are planted in the late winter and early spring. Roundup is used for site preparation in February. Established plantations are fertilized at this time, and weed control begins in March. One of four treatments is applied, depending upon weeds present:

- atrazine and Velpar
- atrazine and Roundup
- atrazine alone
- 2,4-D

In May, Goal or Velpar are sometimes applied. Poast or Roundup are applied as spot treatments. Pre and postemergence herbicides are applied to perennial grasses. It is still difficult to control the following:

- wild carrot
- rattail fescue
- false dandelion
- groundsel
- triazine resistant plants

Asulox is applied in midsummer to control ferns. Berry vines are treated in the fall with Roundup. Kerb is used on grass in November and December.

Spider mites and midges appear in April and early May, although some tree species that bud out late avoid the prime midge infection time. Thiodin is applied then, often in combination with Bravo.

Noble firs do not have the same disease and insect spectrums as Douglas-fir. Nobles seldom have diseases, but insects such as aphids and adelgids cause problems in May and June. The spruce spider mite is a spring and summer pest. Trees are treated for the balsam woolly adelgid in May.

Oregon farmers grow few pines because of the care demands. Lophodermium needle cast is a problem, and during warm and wet weather, pines must be sprayed every month.

Swiss needle cast and Rhabdocline needle cast are serious Douglas-fir diseases, and because Swiss needle cast damage cannot be predicted, trees must be sprayed with a protectant.

Most growers do not have a grass cover crop. (A few of the smaller ones do keep a mulch grass or living sod.) About a dozen years ago, large growers began to use helicopters to harvest their trees, because wet soils in the winter prevented road vehicles from entering the fields.

Comparisons of pesticide use on Christmas tree plantations for 1981, 1987, and 1992 are found in Table 27. A detailed account of pesticide use on Christmas tree plantations in 1992 is found in Table 28.

Table 27. Pesticide Use Comparisons for Oregon Christmas Tree Plantations, 1981, 1987, and 1992.

Herbicides	**1981**	**1987**	**1992**
2,4-D	——	1,300	1,100
Asulam	——	——	490
Atrazine	——	38,000	13,000
Clopyralid	——	——	130
Dalapon	——	370	——
Glyphosate	——	10,000	10,000
Hexazinone	——	14,000	16,000
Oxyfluorfen	——	100	16,000
Pronamide	——	820	——
Sethoxydim	——	190	——
Simazine	——	7,200	——
Triclopyr	——	50	80
Insecticides	**1981**	**1987**	**1992**
Acephate	——	4,500	——
Carbaryl	——	450	——
Chlorpyrifos	——	——	2,900
Diazinon	——	140	45
Dicofol	——	990	60
Dimethoate	——	——	800
Endosulfan	——	6,300	6,000
Fenbutatin-Oxide	——	——	180
Malathion	——	110	70
Oxydemeton-methyl	——	300	1,800
Propargite	——	500	930
Fungicides	**1981**	**1987**	**1992**
Chlorothalonil	——	14,000	32,000
Propiconazole	——	——	630

Table 28. Pesticides Use Estimates for Oregon Christmas Tree Plantations, 1992. 6,159 acres registered with the Oregon Department of Agriculture.

Common Name	Trade Name	Formulated Rate of Application	Method of Application	Acres Treated	Pounds Used a.i.
SITE PREPARATION - Late winter and early spring					
>>>>>>>Weeds: spotted catsear, tansy ragwort, blackberries, poison oak					
2,4-D	Weedone, Envy	0.5 - 1.5 pt/acre	foliar	50 (1%)	30
>>>>>>>Weeds: quackgrass, vetch, mustard					
Atrazine	Atrazine Nine-0	2.0 - 4.0 lb/acre	soil	730 (2%)	3,000
>>>>>>>Weeds: Canada thistle, quackgrass, wild carrot, St. Johnswort, field bindweed					
Glyphosate	Roundup	1.0 qt/acre	foliar	90 (1%)	170
>>>>>>>Weeds: grasses, vetch, spotted catsear, rattail fescue, St. Johnswort, quackgrass, dandelion					
Hexazinone	Velpar L	2.0 - 4.0 qt/acre	foliar, soil	630 (1%)	1,000
ESTABLISHED PLANTINGS - Spring					
>>>>>>>Weeds: mustards, tansy ragwort, false dandelion					
2,4-D	Weedone LV4	0.5 pt/acre	foliar	1,800 (4%)	870
>>>>>>>Weeds: dandelion, grasses, broadleaf plants					
Atrazine	Atrazine 4L, 90DF	2.0 - 4.0 qt/acre	soil	3,100 (8%)	9,800
>>>>>>>Weeds: Canada thistle, groundsel					
Clopyralid	Stinger	0.25 - 0.67 pt/acre	foliar	230 (1%)	40
>>>>>>>Weeds: Canada thistle, quackgrass, groundsel, field bindweed, wild carrot					
Glyphosate	Roundup	1.0 qt/acre	foliar	7,300 (16%)	9,000
>>>>>>>Weeds: wild carrot, fescue, dandelion, groundsel					
Hexazinone	Velpar L	2.0 - 4.0 qt/acre	foliar, soil	11,000 (23%)	15,000
>>>>>>>Weeds: blackberries, Canada thistle, groundsel, pigweed					
Oxyfluorfen	Goal 1.6E	5 - 10 pt/acre	soil	15,000 (32%)	16,000
ESTABLISHED PLANTINGS - Spring					
>>>>>>>Insects: aphids, spruce budworm, cooley spruce gall adelgid, Douglas-fir needle midge					
Chlorpyrifos	Lorsban 4E	1.0 qt/acre	foliar	2,900 (6%)	2,900
>>>>>>>Insects: aphids, Douglas-fir needle midge					
Diazinon	Diazinon 4L	1.0 - 1.5 pt/acre	foliar	100 (1%)	45
>>>>>>>Insects: spider mites					
Dicofol	Kelthane MF	0.75 - 1.0 qt/acre	foliar	120 (1%)	60
Propargite	Omite CR		foliar	600 (1%)	930
>>>>>>>Insects: European pine shootmoth					
Dimethoate	Dimethoate 267	2.0 pt/acre	foliar	1,200 (3%)	800
>>>>>>>Insects: Douglas-fir needle midge, cooley spruce gall adelgid, aphids					
Endosulfan	Thiodan 50WP, 3EC	1.0 - 2.0 lb/acre	foliar	9,300 (20%)	6,000
>>>>>>>Insects: spruce spider mite					
Fenbutatin-oxide	Vendex 4L	1.0 qt/acre	foliar	250 (1%)	180
>>>>>>>Insects: aphids, Douglas-fir needle midge					
Malathion	Malathion 57EC	1.0 - 3.0 pt/acre	foliar	35 (1%)	70
Oxydemeton-methyl	Metasystox-R	1.0 - 2.0 pt/acre	foliar	3,500 (7%)	1,800
>>>>>>>Weeds: Swiss needle cast, rust, rhabdocline, lophodermium needle cast					
Chlorothalonil	Bravo 90DG	2.25 - 4.5 lb/acre	foliar	8,500 (18%)	25,000
	Bravo 500, Bravo 750, Daconil 2787				
Triadimefon	Bayleton	4.0 lb/acre	foliar	315 (1%)	630

Table 28. Continued.

Common Name	Trade Name	Formulated Rate of Application	Method of Application	Acres Treated	Pounds Used a.i.
ESTABLISHED PLANTINGS - Summer					
>>>>>>>Weeds: mustards, tansy ragwort, false dandelion					
2,4-D	Weedone LV4	0.5 pt/acre	foliar	90 (1%)	110
>>>>>>>Weeds: ferns					
Asulam	Asulox	4.0 qt/acre	foliar	200 (1%)	490
>>>>>>>Weeds: Canada thistle, groundsel					
Clopyralid	Stinger	0.25 - 0.67 pt/acre	foliar	450 (1%)	90
>>>>>>>Weeds: grasses, vetch, spotted catsear, rattail fescue, St. Johnswort, quackgrass, dandelion					
Hexazinone	Velpar L	2.0 - 4.0 qt/acre	foliar, soil	90 (1%)	40
>>>>>>>Weeds: blackberries, Canada thistle, groundsel, pigweed					
Oxyfluorfen	Goal 1.6E	5 - 10 pt/acre	soil	30 (1%)	40
>>>>>>>Weeds: Swiss needle cast, rust, rhabdocline, lophodermium needle cast					
Chlorothalonil	Bravo 90DG Bravo 500, Bravo 750, Daconil 2787	2.25 - 4.5 lb/acre	foliar	1,500 (3%)	6,500
LATE SUMMER					
>>>>>>>Weeds: poison oak, berry briars					
Glyphosate	Roundup	1.0 qt/acre	foliar	680 (1%)	850
2,4-D	Weedone LV4	0.5 pt/acre	foliar	50 (1%)	50
Triclopyr	Garlon 3A	1.25 pt/acre	foliar	50 (1%)	50
>>>>>>>Weeds: blackberries, spotted catsear					
Triclopyr	Garlon 3A	1.25 pt/acre	foliar	60 (1%)	30

Nursery Crops

Production

The dynamic Oregon nursery crop industry is familiar with high costs, high risks, and high rewards. Small nurseries make up over three-quarters of the licensed growers and are overshadowed by the giants who handle most of the business, take the greatest risks, and suffer the greatest losses. Each year, Oregon nurseries employ over 18,000 people and pay wages totaling close to $100 million. About 80 percent of the nursery production is sold outside the state. Sales average over $10,500 an acre for outdoor crops and $3 per square foot for greenhouses.

Approximately 24,000 acres of land are in outdoor nursery production and 450 acres in greenhouse production. Nurseries grow thousands of different ornamental plants that can be divided into at least five general categories (with some overlap):

- field trees and shrubs
- container stock
- color and bedding plants
- ornamental bulbs
- cut flowers

Historical Pesticide Use

Some general statements can be made about the role of pesticides in the growth of the nursery business. Many nurseries were started as vegetable and small fruit farming operations that grew their own plant stock. Over time, producing plant stock for others became more profitable, and the nursery business became more important. Farm pest control practices were incorporated into the nursery. Today's standards for blemish-, insect-, and disease-free plants were unknown prior to World War II. Only small amounts of pesticides were used: sulfur and copper for leaf and blossom diseases, tobacco with extracts and oil for insect control. To avoid pest buildups, farmers rotated nursery crops into grass, legumes, or other dissimilar crops.

Practices changed, however, with the advent of new pesticides after the war. In the years following World War II, many pesticides were, at one time or another, applied to a nursery crop. This was because just about every type of disease, insect, and weed could be found in nurseries. In general, from the end of the war to about 1970, soil-borne insects, such as weevils, were controlled with these chemicals:

- aldrin
- dieldrin
- DD
- Telone

Foliar insects were controlled with the following:

- DDT
- malathion
- diazinon
- Sevin

Diseases are managed with EBDCs (Ethylene Bisdithiocarbamates), coppers, and sulfurs. Diuron and simazine are used for weed control. Since 1970, the number and amounts of pesticides applied have increased as the nursery industry expanded. In 1987, OPIAP counted 53 pesticides used. Today, the level of pesticide use has declined because of new technologies and because of concerns about worker exposure and pesticide residues on plants. Table 29 compares pesticide use on Oregon nursery crops for the years 1981, 1987, and 1992.

Pesticides must be registered for use on a wide variety of ornamental crops for the nursery growers to achieve effective pest management. For example, a pesticide registration for woody ornamentals is more useful than a registration for azaleas. Because these plants are grown in close proximity to one another, a great deal of time and cost is involved in applying the right pesticide to the right crop. If azaleas and rhododendrons are grown next to each other but cannot be treated with the same insecticide, the labor cost is multiplied. Several of the large nurseries underwrite research by university specialists, private agricultural advisors, and others to test pesticides for efficacy and phytotoxicity. Plants must be perfect to sell. A manager must group the plants according to water and space needs before considering pesticide needs. Pesticides must not burn the plant or leave unsightly residues. Pesticide residues or phytotoxicity make plants unsalable and result in shipping delays.

Plant quarantines are significant when considering economic thresholds for pests. For example, an Illinois inspector who finds one root weevil in a load of plant material has the authority to reject the entire shipment. Thus, in the case of root weevils, the economic threshold is one weevil. Economic thresholds for pests are determined by the damage the pest inflicts, the consumer's acceptance of the appearance, and the report of the state plant inspector.

Other quarantines require specific chemical treatments. Growers who wish to ship apple trees out of Yamhill County must follow a prescribed spray program for the apple ermine moth, regardless of whether or not the insect is present. Quarantines help the Oregon nursery industry avoid importing plant materials that are infested with Japanese beetles or gypsy moths. For nurseries that ship plants around the nation and the world, quarantines are essential because they stop the transport of plant pests through commerce.

Pest Management Practices

Container Nurseries

In nursery terminology, "containers" means potted plants, first used to a noticeable extent in the 1950's. Rooted cuttings or other plants are potted in a mix that is sometimes the discarded potting mix from unsold containers. Or, one or more of the following can be used:

- bark dust
- loamy soil
- sand
- processed sewage sludge
- peat moss
- compost

Often, potting mix is fumigated with methyl bromide or subjected to high temperature through composting or live steam. This kills insects, soil-borne diseases (such as *Verticillium* and *Fusarium*), and weed seeds, cutting herbicide use by as much as two-thirds.

Pots are placed on long gravel beds and spaced to allow good ventilation, which decreases the incidence of serious foliar diseases such as *Botrytis* or leaf spot. A gravel bed allows easy transport in the winter when the ground would otherwise be muddy. It also prevents weeds from growing in the area surrounding the pots. However, many weeds are able to grow up through the gravel. Normally, Surflan, Goal, or simazine is applied to vacant gravel beds to minimize weed growth. Potted plants may also be placed on black plastic or a special cloth, but this practice is more common in small nurseries. Containers are also placed in shade houses and greenhouses.

Row width is determined by the type of equipment used for such operations as treating the plants with pesticides. While this is true of pesticide application by ground sprayers, helicopters, by virtue of their maneuverability do not influence row spacing. The size of plant cover used to protect plants against the cold and wind in the winter can also determine row width.

In many of the larger nurseries, irrigation water is recycled using a sophisticated tiled drainage system (complete with ponds). This decreases the need for new water each year and also allows the nutrients that were not held by the container to move through the soil and back into the ponds. Drainage tiles help remove excess moisture and reduce the incidence of *Phytophthora* and other root rots. Recycled water is chlorinated or brominated to destroy pathogens. Because moisture on plant tissues can significantly increase incidence of disease infection, the timing and frequency of irrigation are important factors in disease control.

Weeds can be a serious problem in containers. Some of the following are major weeds:

- groundsel
- popweed
- annual bluegrass
- oxalis
- bittercress
- liverwort
- fireweed
- pearlwort

Pearlwort was introduced into one nursery from Canadian peat moss in 1981 but is found at many nurseries. Pearlwort forms a mat in each container, providing a habitat suitable for root weevils. The seed is very small and is easily transported by wind and water, spreading the infestation. Rout or Ornamental Herbicide II (OH II) granules applied three times a year help control pearlwort. Hand pulling, though not cost effective, is the only way to remove pearlwort. Many winter annuals can be controlled by treatment with these chemicals:

- Ronstar
- Devrinol
- Rout
- OH II

But weeds like groundsel are especially difficult to control when herbicides cannot be applied early enough. Granular formulations tend to stick to the foliage but are otherwise well suited for potted plants. Snapshot, XL, and Southern Weed Grass Control are used in granular form for weed control. Spray formulations include pendamethalin, metolachlor, and Gallery. These chemicals are used for some spot spraying:

- Roundup
- Surflan
- pendimethalin
- diquat

Although weeds are the same, diseases and insects affect different plant species. Rust and leaf gall are serious pests on azaleas; blight is a problem on junipers. Rhododendrons, azaleas, and conifers are susceptible to phytophthora or cylindrocladium root rots. *Phomopsis* is a serious disease on woody ornamentals such as certain arborvitae. Fungicides used in container nurseries to control this disease are as follows:

- copper
- Bayleton
- Daconil
- mancozeb
- Subdue
- Alliete
- Agri Strep
- Cleary 3336
- Domain
- Chipco 26019

Kocide DF is applied as a preventative. Some *Pseudomonas* strains are somewhat resistant to streptomycin and copper. *Phytophthora* is generally treated with Alliete or Subdue drench. Shothole leaf disease is treated with Daconil or Fungo-Flo. *Botrytis*, a problem on potted greenhouse plants, is treated with mancozeb. There has been a tendency to move away from any pesticide listed on California's Proposition 65. (Proposition 65 listed chemicals that were carcinogens or suspected carcinogens.) Although growers are not forbidden to apply listed chemicals, there is concern that buyers may reject plants treated with any of these chemicals.

High greenhouse humidity provides a hospitable environment for fungus gnats and shore flies, as well as such diseases as *Botrytis* and mildews. In some greenhouses, computers regulate humidity by controlling ventilation and using outside air, which is generally less humid. Greenhouse fungus disease can be reduced or eliminated by water treatment and sanitation. Water used for plant care, especially in propagating areas, is sometime treated with Agri-Brome to help prevent diseases. Greenhouse walls are washed, sometimes with Naccosan, and all debris on the floor is removed and burned.

Root weevils are one of the most serious insects that attack container plants. In some states, plants infested with root weevils are quarantined. Because primroses are a favorite weevil food, they are often used to detect weevil emergence. Even though the potting soil is free of pests, plants often are an insect host by the time they are sold. Sometimes, weevils are brought in on other plant material, but usually enough weevils live in the surrounding region, and its host range is large enough that they are always present. Before 1980, chlordane was used against weevils, and they were not the serious problem they are today. Orthene is frequently applied in June, but Pageant, Talstar, and Turcam can be used in subsequent treatments. Weevils are nocturnal, and plants are treated at night. Nematodes used to control weevil larvae are about 80 percent effective, but the economic threshold is zero when plants are shipped into quarantine areas.

Mites—the twospotted spider mite and others—are serious pests. When plants (such as junipers) have enlarged sufficiently to fill all vacant spacing between pots, mites are difficult to control because spray equipment cannot reach into the protected areas. Chemical controls against mites include these:

- light oils
- Pentac
- Talstar
- Vendex
- Ornamite
- Avid
- Mavric Aquaflow
- Impede
- Morestan

Many other pests also are present in container nurseries:

- cypress tip moth
- white pine weevil
- pine shoot moth
- aphids
- spittlebugs
- thrips
- scale

When natural predators fail, diazinon, Orthene, and chlorpyrifos are commonly applied.

A modest examination of pesticides applied to Oregon container nurseries is found in Table 30.

Color and Bedding Plants

These are potted seedling flower and vegetable plants typically sold at retail stores. Most often, they are grown in greenhouses, and three crops are produced each year.

Extensive greenhouse screening is done at some nurseries to prevent insect entry. Biological control with parasitic nematodes and incarsia (sometimes used against white flies) has had mixed results. Other insecticides used include Enstar and pyrethrums such as resmethrin. Most spraying is done at night.

The major insect pest on color and bedding plants is the white fly, and it must be treated weekly. Some nurseries use a waterwand with fogger nozzles applied at 30 psi to the underside of the leaves. Higher pressures will scour the leaves. Other nurseries use electrostatic sprayers for low volume spray to apply these treatments:

- Talstar
- Avid
- Tame
- Plantfume
- Dibrom
- Orthene

Yellow sticky cards are used to indicate the presence of white flies. Fungus gnats and shore flies are monitored and *B.t.* is applied as a drench in three weekly applications to control them. Aqua Brome (brominated water) controls algae in many nursery holding ponds and reduces populations of both pests. Thrips can also be a problem.

Botrytis, leaf spot, and virus diseases can also infect plants. Tomato spotted wilt virus, transmitted by thrips, is devastating because affected plants are not salable. *Xanthamonas* on geraniums is equally devastating. Controlled watering is an important part of disease control. Some drip and overhead irrigation is used. Timely ventilation in the greenhouses is important to remove excess moisture that may cause a buildup of water on the structure and the plants. Early morning fog will form in a greenhouse, but air ventilation helps remove excess moisture and prevents fog formation. Each type of greenhouse has its own peculiarity and must be managed differently. A black ground cloth is sometimes used to prevent moisture from entering the greenhouse. These methods greatly reduced the incidence of such diseases as *Botrytis*.

Mice in greenhouses eat the terminal buds of ornamental cabbage and kale, causing multiple heads. Heavy screening hardware cloth or other mechanical barriers can deter the mice. Or, greenhouse floors can be covered with gravel, which deters mice from entering by making digging difficult. Traps and rodent baits are also used.

Oxalis and groundsel are the most common and persistent weed problems, but fireweed is also troublesome in containers. Simazine was used in the past for "on premises" weed control, but glyphosate is the primary herbicide used for greenhouse weed control. Managing the nighttime temperature causes some plants to grow more slowly and reduces the need for plant growth regulators.

More information about pesticide use on color and bedding plants can be found in Table 31.

Field Trees and Shrubs

Deciduous and evergreen trees and shrubs are grown in rows that are 5 to 6 feet in width. After growing for 2 to 4 years, trees or shrubs are balled in burlap and sold or are sold bare root.

Many weeds affect evergreen trees and shrubs. Problem weeds differ depending upon the rotation crop or the past history of the field. For example, corn spurry is a problem in fields that previously produced caneberries. Tuber oatgrass is a problem in fields that were previously pasture land. The following weeds continue to be a problem for growers:

- bindweed
- quackgrass
- nutsedge
- groundsel
- shepherdspurse
- bittercress
- nightshade
- annual bluegrass
- dog fennel
- redstem filaree
- Canada thistle

Following planting, plants are tractor cultivated or hoed during the first season. Special narrow tractors are used, and ground is cultivated about every 2 weeks throughout the growing season. In the fall, these herbicides are applied to control germinating winter annual weeds:

- Devrinol
- Surflan
- Ronstar
- Gallery
- Rout
- Ornamental Herbicide II
- Pennant
- simazine

Herbicides are rotated over the life of the crop to avoid buildup of dominant weeds. Paraquat and Roundup are applied as a foliar spray when needed. Throughout the winter, weeds continue to germinate in western Oregon nurseries. In the spring, another soil herbicide is applied in a band in the tree row. It is common for herbicides to be applied at half the label rate to avoid plant damage and herbicide buildup. Stinger is used occasionally to control Canada thistle. Poast is applied to control quackgrass and other grasses.

A few nurseries plant strips of grass or grain between the tree rows. This provides a stable bed for equipment in the winter and spring months when rains are abundant. Cereal grains sometimes are planted to provide erosion control on slopes. Other nurseries clean-cultivate between the tree rows until the tree canopies close. In some nurseries, a preplant herbicide such as Gallery is incorporated, and a grain or grass cover crop is grown when the ground is not in nursery production. This mulch crop is turned under.

Phytophthora, verticillium wilt, and weeds are treated by incorporating methyl bromide with chloropicrin into the soil before the nursery crop is planted. However, this combination is very hard on the microflora and causes difficulty in soil management when amendments such as sewage sludge are incorporated. As a result, Vapam is now being considered as a replacement chemical.

There are a variety of tree and shrub insect pests:

- aphids
- leafrollers
- mites
- *Lygus*
- scale
- symphylans
- leafminers
- weevils
- midges

Thrips can be a problem in maples if a cereal crop adjacent to the nursery is cut. The obliquebanded leafroller is a pest in the spring, especially on nursery fruit trees. California quarantines trees infected with the pine shoot moth, and these trees must be certified by the state. In the past, Cygon was applied to control the moth, but the label has been dropped, and today, growers apply Orthene or chlorpyrifos. The woolly aphid is a major pest on ash trees and is controlled by treatment with:

- oil
- Orthene
- diazinon
- MSR

Twospotted spider mites and Eriophyid mites are sometimes controlled with Ornamite or Vendex. Higher populations of spider mites can be tolerated because they do not make a tree unsalable as do insects that attack the terminal bud and cause the plants to be deformed. Dyfonate is applied where symphylans are a recurring problem.

Honeylocust pod gall midge is treated with MSR or diazinon. Some pests such as the white pine weevil can be eliminated by pruning.

Disease pests tend to be specific to a plant species. However, some diseases that are more important to control include these:

- *Verticillium*
- apple scab
- rusts
- brown rot
- *Pseudomonas*
- fusarium canker
- nectria canker
- *Botrytis*
- crown gall
- *Phytophthora*

Spruce needle cast is an annual problem on seedling spruce. Hazelnut trees infected with eastern filbert blight must be destroyed. Root rots continue to infect rhododendrons and junipers. Some of these diseases can be averted by changing digging dates or by reducing plant stress. Resistant plant varieties are grown whenever possible, and susceptible varieties such as crabapples, which promote scab, are avoided. Reduced rates of fertilizer in the late summer combined with less frequent irrigation will allow new shoot growth to harden in trees susceptible to *Pseudomonas*.

Daconil plus copper is normally applied to control Swiss needle cast. Copper alone is used as a protectant from pseudomonas; Agri Strep is often added to increase efficacy. Growers tend to prefer to use Bayleton rather than Cleary 3336 to control leaf rusts. Dodine is used for scab, Daconil for brown rot, Fore for anthracnose. Subdue and Chipco or Aliette are applied to treat root diseases.

Table 32 contains information on 1992 pesticide use on field tree and shrub crops.

Cut Flowers

Oregon has many varieties of cut flowers that are taken from greenhouses and the field. While many perennial and annual flowers are produced, some of the most important are these:

- roses
- peonies
- forsythia
- holly
- boxwood
- curly willow
- skimmia
- camellia

The mother plants are normally put in the field as permanent plants; sod is commonly planted between the rows to serve as a living mulch. This practice cuts the use of herbicides by as much as 80 percent. The grasses used are dormant in the summer and winter and reduce tractor cultivation time by 40 percent. Fusilade and Poast are applied to control the grass growth.

The plant rows are treated with Roundup early in the season when plants are dormant. Persistent weeds in the tree rows include the following:

- prickly lettuce
- mustard
- bull thistle
- Canada thistle
- vetch
- bedstraw
- berries

Berry plants are generally dug out.

Pseudomonas can infect holly and forsythia, especially during late fall and early spring rains. Agri Strep and Champ are used in repeated applications throughout the spring to prevent *Pseudomonas*. Early fall fertilization to promote healthy growth, combined with two more applications of Agri Strep or Champ, has also helped fight infestations. *Phytophthora* and *Pseudonectria* are boxwood greenhouse diseases. Downy mildew, powdery mildew, and *Botrytis* are all greenhouse diseases that affect roses and other ornamental plants. Brown rot blossom blight is a problem on flowering cherry and peach. Anthracnose infects dogwood; fire blight attacks camellias. Root rots are treated with Subdue that is applied as a drench.

Plants grown in the greenhouses are planted in beds that are either permanent or placed on pallets. The soil varies, but it is often a mix of easily obtained mulches such as hazelnut refuse and alder bark. These and other constituents lighten the soil. Roses growing in these mulch soils normally produce flowers for 5 to 8 years before being replaced with newer disease-free vigorous plants. If roses remain in the beds, they will decline because root systems become too crowded, and diseases present in the plant and soil continue to increase. Plant diseases in the greenhouses are treated when found: Plantvax is applied when rust is a problem; Milban treats mildew; and sodium bicarbonate plus oil is used against powdery mildew. When plants are removed from the greenhouses, these treatments can be applied:

- Fore
- Cleary 3336
- Difolatan
- copper

Outdoors, lime sulfur and oil are applied to boxwood for twospotted spider mites and skimmia mites. Thrips, aphids, and mites are controlled in greenhouses with Dibrom 8, which is applied by steam plant fumigation every 3 weeks throughout the season. Outdoor plants with mites are treated with Talstar or Pentac. Root weevils in rhododendrons and camellias are continual pests, and Orthene is normally used to control the adults. The boxwood leafminer is very difficult to control because it can only be effectively treated for about three weeks out of the year when it is an adult. MSR is sometimes used. The holly cottony scale and camellia worm are pests controlled with Orthene and oil. Many plants must be moved out of the greenhouses before they can be treated.

A detailed account of pesticide use on Oregon cut flowers in 1992 can be found in Table 33.

Ornamental Bulbs

Oregon growers produce many ornamental bulb crops, including these:

- tulips
- daffodils
- lilies
- irises
- dahlias

Most of these bulbs are grown in a long rotation that requires 3 to 7 years between bulb crops. All but lily bulbs are grown in the Willamette Valley area from Savies Island to Roseburg. About 300 acres of lilies are grown at Brookings, as near to the coast as possible.

Tulips and daffodil bulbs

Before growers plant tulips in the fall, they dip them in a solution containing benomyl or Cleary 3336 plus Mertect. Before planting, tulips are cooked at 111 degrees for 3 hours to kill nematodes. Because this is not totally effective, Nemacur is applied at planting. If the bulbs are cooked too long, they will not flower.

Paraquat is applied if weeds are germinating in the new planting bed. The fields are spot treated with paraquat during the winter. After planting, Devrinol is broadcast to control germinating winter annuals. Troublesome weeds including annual ryegrass, shepherdspurse, brassicas, and dog fennel are mostly winter annuals and must be controlled with Devrinol in the fall. If they are allowed to grow, the fields become a mass of weeds that can only be eliminated by hand weeding. Because the bulbs do not grow until January, cultivation is kept to a minimum.

Just before the tulip buds open, the fields are inspected for fireheads (a bud loaded with spores), fire blight, or *Botrytis*. Growers remove all the flower heads and treat the fields with Chipco 26019 to control the diseases. Flower tops must be removed immediately because they host *Botrytis*. This may be done one to four times depending upon the pest pressure. In 1992, one treatment was sufficient. Break virus is a disease spread by aphids. The flowers that exhibit symptoms are rogued out. Plants are sprayed with a 1 percent oil suspension with Orthene, which puts a thin film on the plant to decrease incidence of virus. After tulips bloom, they are treated with mancozeb. Following June harvest, tulips are sized and put into trays where they are air dried to control disease.

Daffodils are not as susceptible to *Botrytis*, fire blight, and virsuses. Daffodils are stored in a forced air facility to aerate the bulbs, keeping them free from moisture, which may lead to rot diseases. The bulbs send up shoots in the winter and bloom in the spring. In May, Proxall is applied as a drench to control the narcissus bulb fly.

Easter lily bulbs

Lilies are grown along the coast (from Brookings, Oregon to California) on a strip about 25 miles long and a mile wide. In earlier years, lilies had been grown from Vancouver, BC to the Bay area, but diseases and metropolitan growth have forced the industry into a very small area. Lilies are grown in rich humus soils (15 to 25 percent organic matter) and are rotated for 3 to 4 years into clover, ryegrass, orchard grass, or row crops. A lily bulb will take 2 years to mature when grown from a bulblet and 3 years when grown from a scale. Bulbs are lifted each year and replanted in order to control disease and to maintain the proper planting density and bulb depth.

All land planted into bulbs is fumigated with methyl bromide or Telone to control nematodes. Clover and row crop cover crops increase the nematode populations. Telone is not registered in California, and Vapam and Mocap are being tested as substitutes. Methyl bromide scarifies clover and vetch seed and when applied will cause a very heavy flush of clover and vetch.

Bulbs and scales are planted from the second week of August to the end of October. All bulbs and scales are dip drenched with a combination of Terrachlor, thiram, Banrot, and Vitavax. California bulb growers apply Thimet granules (registered only in California) to the rows. Oregon growers use Nemacur, which is registered only in Oregon. Growers whose land crosses the border must apply one chemical on the California side and the other on the Oregon side. Temik was used in the past, but is no longer registered.

Weeds are cultivated out until the rains begin. Afterwards, Roundup is applied to control germinated winter annuals. In the past, these weeds were controlled with Paraquat. The most troublesome weeds are these:

- clover
- dock
- corn spurry
- knotweed
- groundsel

During the wet mild winter, weeds that are hoed out but left in the row will continue to grow, flower, and produce weed seed. Therefore, in the middle of winter, growers apply Devrinol and Direx to control weeds that would otherwise go to seed.

During the 1986 to 1992 drought, *Botrytis* was not a serious problem. However, with the onset of an unusually wet winter and spring, it has become disastrous. The 1992 crop was the best in the history of the crop, and the 1993 crop may be the worst. Fire blight is also a serious disease. Plants are rogued out by hand to help control the disease. There are 25 identified diseases that infect bulbs: *Botrytis* and fire blight head the list. Other diseases include these:

Rhizoctonia
Fusarium
Pithium
Pseudomonas

Growers normally begin disease control with a January application of Bordeaux after the lilies have emerged. Subsequent treatments are done with Kocide 101, Kocide DF, and Champ. Farmers also apply Daconil, mancozeb, and Chipco 26019.

Growers treat for aphids in April and May. In the past, Temik controlled aphids; today, Furadan and DiSyston are used. Occasionally, a small amount of Sevinor or diazinon is used.

Blossom buds are picked in June and July to eliminate the major host source for *Botrytis* inoculum. Sprout Nip is applied in March as a chemical debudder, and buds are also removed by hand. Debudding also increases the size of the bulb.

Yearling bulbs are lifted in the summer and replanted. In September and October, the commercial sized bulbs are harvested, packed in peat moss, and trucked away to cold storage facilities until the Easter season. Several weeks before Easter, bulbs are planted in greenhouses where they develop into Easter lilies.

Iris rhizomes

About 500 acres of irises are grown commercially in Oregon, mainly in the northeast Willamette Valley. Irises are normally planted in a wheat-bushbean-wheat 4-year crop rotation. To prevent water erosion over the winter, fields are not deep plowed. Instead, they are deep chiseled to open the soil and are planted with iris rhizomes in September and October. Occasionally, a portion of a field may be treated with methyl bromide to retard disease in transplanted seedling stock. Rhizomes are dipped in these chemicals:

Terrachlor
Benlate
Cleary 3336
Daconil

Each rhizome has about 6 inches of leafy tissue. Growers apply Terrachlor drench in the spring to prevent mustard seed mold. Soil is disk hilled over the plants in the fall to prevent freezing and thawing on the surface of the rhizomes. This also reduces the incidence of *Botrytis*. In addition, the practice protects against frost heaving and keeps the plants above the water during the winter.

If possible, simazine and Devrinol are applied in the winter to control germinating winter annual weeds. Where the treatment is not applied, pineapple weed, groundsel, volunteer wheat, and many other weeds grow to a height of 4 feet and completely cover the irises. The fields are also hand hoed 2 or 3 times in the spring, at a cost of about $180 per acre per year.

In March, the soil that had covered the plants is removed and cleared away from the plants by hand. Plants are spaced 11 inches apart in rows that are 42 inches apart. This allows plenty of air circulation, an important practice that prevents serious outbreaks of leaf spot. Following soil removal, Kocide 101 is applied for leaf spot. In April, a second treatment for *Botrytis* and leaf spot is applied—Bayleton or Cleary 3336. Eventually, the sunshine will clear up any remaining leaf spot. When weather warms, Dimethoate 267 is added to the fungicide application for aphid control.

During the mid-May to early-June bloom season, plant varieties are verified. There are about 1000 varieties. Bloom stalks are cut off afterward, and plants are lifted from the field in July, August, and September, when transplanting begins.

Other bulb crops

Over 500 acres of assorted types of bulb crops are grown in the Columbia Basin area of eastern Oregon. Other bulb crops are grown on Savies Island near Portland.

A comparison of pesticide use on Oregon ornamental bulbs for 1981, 1987, and 1992 can be found in Table 34.

Table 29. Pesticide Use Comparisons for Oregon Nursery Crops, 1981, 1987, 1992.

Fungicides	1981	1987	1992
Benomyl	1,400	2,500	1,500
Captan	——	220	——
Chlorothalonil	——	1,500	3,600
Copper	——	12,000	25,000
Bordeaux	88,000	——	3,000
DCNA	——	100	——
Dodemorph acephate	——	——	100
Dodine	——	100	320
Etridazole	——	——	270
Fenarimol	——	——	30
Ferbam	14,000	1,000	——
Fosetyl-Al	——	——	450
Imazalil	——	——	1
Iprodione	——	——	1,000
Lime sulfur	——	1,000	900
Mancozeb	——		3,700
Maneb	——	600	——
Metalaxyl	——	470	170
Oxycarboxin	——	——	10
PCNB	14,000	940	1,000
Propionazole	——	——	30
Streptomycin sulfate	——	——	410
Sulfur	——	600	——
Thiobendazole	——	——	200
Thiophanate-methyl	——	——	1,900
Thiram	——	——	100
Triadimefon	——	100	140
Triforine	——	200	——
Triflumizole	——	——	130
Vinclozolin	——	100	50

Herbicides	1981	1987	1992
Benefin	——	——	200
Bifenox	——	600	——
Clopyralid	——	——	50
Dichlobenil	——	2,000	4,200
Diphenamid	——	400	——
Diquat	——	——	60
Diuron	——	2,400	500
Fluazifop-butyl	——	——	10
Glyphosate	——	2,100	870
Hexazinone	——	24	——
Isoxaben	——	——	1,500
Metolachlor	——	——	2,100
Napropamide	——	3,400	15,000
Oryzalin	——	1,000	14,000
Oxadiazon	——	——	10,000
Oxyfluorfen	——	320	18,000
Paraquat	300	60	170
Pendimethalin	——	——	4,400
Pronamide	——	200	——
Sethoxydim	——	100	230
Simazine	1,300	300	2,500
Triclopyr	——	20	——

Insecticides	1981	1987	1992
Abamectin	——	——	20
Acephate	——	650	8,700
Aldicarb	1,500	——	——
Azinphos-methyl	——	200	80
Bacillius thuringiensis	——	4	3,000
Bendiocarb	——	40	3,300
Bifenthrin	——	——	7,800
Carbaryl	——	600	50
Carbofuran	——	780	500
Chlorpyrifos	——	580	6,900
Diazinon	——	800	2,600
Dicofol	——	200	——
Dienochlor	——	——	260
Dimethoate	——	140	1,100
Disulfoton	——	100	500
Endosulfan	——	100	80
Fenamiphos	——	880	280
Fenbutatin-oxide	——	100	510
Fenpropathrin	——	——	1
Fenvalerate	——	35	——
Fluvalinate	——	——	24
Fonofos	——	300	2,100
Kinoprene	——	——	1
Malathion	——	400	——
Metaldehyde	——	600	——
Methiocarb	——	100	——
Naled	——	——	13,000
Oil	——	3,500	21,000
Oxycarboxin	——	——	100
Oxydemeton-methyl	100	100	170
Oxythioquinox	——	——	1,300
Phosmet	——	——	100
Propargite	——	10	1,000
Pyrethrins	——	100	100
Resmethrin	——	——	1
Sulfotepp	——	——	unknown
Temephos	——	——	14
Trichlorfon	——	——	23,000

Plant Growth Regulators	1981	1987	1992
CIPC	500	——	900

Water Treatment	1981	1987	1992
Bromine	——	——	unknown
Chlorine	——	——	unknown

Fumigants	1981	1987	1992
1,3-dichloropropene	63,000	22,000	20,000
Aluminum phosphide	——	200	——
Chloropicrin	——	——	1,800
Metam-sodium	——	320	12,000
Methyl bromide	——	21,000	92,000

Table 30. Pesticides Use Estimates for Oregon Container Nursery Crops, 1992. 3,200 acres.

Common Name	Trade Name	Formulated Rate of Application	Normal Method of Application	Acres Treated	Pounds Applied a.i.
WEED CONTROL - premises, on container beds					
>>>>>>>groundsel, annual bluegrass					
Simazine	Princep, Simazine	2.0 - 4.0 lbs/acre	broadcast	160 (05%)	240
Oxyfluorfen	Goal 1.6E	5.0 - 8.0 pt/acre	broadcast	320 (10%)	440
Oryzalin	Surflan	2.0 - 4.0 qt/acre	broadcast	320 (10%)	960
WEED CONTROL - in containers					
>>>>>>>groundsel, popweed, annual bluegrass, oxalis, bittercress, liverwort, fireweed, pearlwort					
Oxyfluorfen +	Ornamental Herbicide II		granular	960 (30%)	5,700
Pendimethalin		2.0 lb + 1.0 lb a.i./acre			2,900
Oxyfluorfen +	Rout		granular	960 (30%)	5,700
Oryzalin		2.0 lb + 1.0 lb a.i./acre			2,900
Oryzalin +	Snapshot		granular	160 (05%)	320
Isoxaben		2.0 lb + 4.0 lb a.i./acre			640
Napropamide	Devrinol 50DF	8.0 lb/acre	broadcast	480 (15%)	1,900
Oryzalin	Surflan	2.0 - 4.0 qt/acre	broadcast	320 (10%)	800
Oxyfluorfen	Goal 1.6E	5.0 - 8.0 pt/acre	broadcast	320 (10%)	420
Oxadiazon	Ronstar G	2.0 - 4.0 lb a.i./acre	granular	160 (05%)	480
Benefin +	XL-2G	100 - 150 lb/acre	granular	160 (05%)	200
Oryzalin					200
Pendimethalin	Southern Weed Grass Control		granular	160 (05%)	400
Isoxaben	Gallery 75DF	0.66 - 1.33 lb/acre	spray	320 (10%)	320
Metolachlor	Pennant	2.0 - 3.0 pt/acre	spray	320 (10%)	800
Diquat	Diquat	1.0 qt/acre	spot treatment	64 (02%)	64
Glyphosate	Roundup	1.0 qt/acre	spot treatment	320 (10%)	320
SOIL FUMIGATION					
>>>>>>>weed seed, soil-borne diseases, insects					
Methyl bromide		1.0 lb/three cubic yard soil mix	fumigate	—NA—	
IRRIGATION HOLDING PONDS					
>>>>>>>pathogens					
Chlorine			water treatment	—NA—	
Bromine	Agri-Brome	5 - 10 ppm	water treatment	—NA—	
DISEASES					
>>>>>>>*Botrytis*, leaf spot, rust, leaf gall, mildew, root rots, *Phomopsis*, anthracnose, *Pseudomonas*, *Pythium*, *Phytophthora*					
Copper	Kocide 101, Champ	1.0 lb/100 gal	foliar	1,920 (60%)	1,900
Triadimefon	Bayleton 50W	2.0 oz/100 gal	foliar	64 (02%)	10
Chlorothalonil	Daconil 2787 WDG	1.25 lb/100 gal	foliar	480 (15%)	540
Mancozeb	Dithane, Manzate	1.0 - 3.0 lb	foliar	640 (20%)	1,000
Metalaxyl	Subdue 2E	1.0 - 4.0 fl oz/100 gal	drench	640 (20%)	40
Fosetyl-Al	Chipco Aliette	6.4 - 12.8 oz/100 gal	drench	320 (10%)	180
Streptomycin sulfate	Agri Strep	50 ppm	foliar	160 (05%)	8
Thiophanate-methyl	Cleary 3336	1.0 lb/acre	foliar	160 (05%)	120
Imazalil	Fungo Flo		foliar	160 (05%)	10
Iprodione	Chipco 26019	1.0 - 2.0 lb/acre	foliar	800 (25%)	600
Vinclozolin	Ornalin 50W	0.5 - 1.0 lb/acre	foliar	64 (02%)	25
Triflumizole	Terraguard 50W	4.0 - 8.0 oz/100 gal	foliar	32 (01%)	130

Table 30. Continued.

Common Name	Trade Name	Formulated Rate of Application	Normal Method of Application	Acres Treated	Pounds Applied a.i.
INSECTS					
>>>>>>>aphids, thrips, root weevils, spider mites, moths, scale, shore flies, fungus gnats, white flies					
Acephate	Orthene 75SP	1.3 ib/acre	foliar	1,300 (40%)	1,300
Chlorpyrifos	Pageant 50DF	2.0 lbs/acre	foliar	1,300 (40%)	1,500
Bifenthrin	Talstar	1.0 - 2.0 lb a.i./100 gal	foliar	960 (30%)	4,300
Bendiocarb	Turcam	1.0 - 2.0 lb/100 gal	foliar	960 (30%)	3,300
Oil + impede	Supreme Oil	2.0 qt/100 gal	foliar	480 (15%)	1,400
Dienochlor	Pentac 50W	12 - 16 oz/100 gal	foliar	480 (15%)	240
Fenbutatin-oxide	Vendex 50W	8 - 16 oz/100 gal	foliar	320 (10%)	120
Propargite	Ornamite	1.5 lb/acre	foliar	160 (05%)	70
Abamectin	Avid .15EC	4.0 fl oz/100 gal	foliar	160 (05%)	10
Fluvalinate	Mavrik, Spur	4 - 10 fl oz/gal	foliar	160 (05%)	20
Oxythioquinox	Morestan 4L	1.0 - 2.0 pt/100 gal	foliar	640 (20%)	480
Diazinon	Diazinon 50W	1.0 - 2.0 lb/acre	foliar	160 (05%)	120
Phosmet	Imidan 50W	1.0 - 1.5 lb/100 gal	foliar	160 (05%)	100
Azinphos-methyl	Azinphos-methyl 2	1.0 - 3.0 pt/100 gal	foliar	160 (05%)	80
Endosulfan	Thiodan 50W	1.0 lb/100 gal	foliar	160 (05%)	80
Temephos	Tempo 2	5 - 10 lb/acre	foliar	96 (03%)	15

Table 31. Pesticides Use Estimates for Oregon Color and Bedding Plants, 1992. 1,000 acres.

Common Name	Trade Name	Formulated Rate of Application	Normal Method of Application	Acres Treated	Pounds Applied a.i.
WEED CONTROL - on bedding floor					
>>>>>>>oxalis, groundsel, fireweed, pearlwort					
Simazine	Princep, Simazine	2.0 - 4.0 lb/acre	broadcast	100 (10%)	200
Glyphosate	Roundup	1.0 qt/acre	spot spray	400 (40%)	40
IRRIGATION HOLDING PONDS AND TANKS					
>>>>>>>pathogens, algae, shore fly, fungus gnat larvae					
Bromine	Agri-Brome	5 - 10 ppm	water treatment	—NA—	
DISEASES					
>>>>>>>*Botrytis*, leaf spot, viruses, *Xanthomonas*					
No chemical controls used					
INSECTS					
>>>>>>>aphids, whiteflies, fungus gnats, shore flies, thrips					
Acephate	Orthene 75S	1.25 lb/acre	foliar spray	100 (10%)	2,000
Abamectin	Avid .15EC	4.0 fl oz/100 gal	foliar spray	50 (05%)	10
Fenpropathrin	Tame		foliar spray	50 (05%)	10
Sulfotep	Plantfume		foliar spray	50 (05%)	10
Naled	Dibrom 8	3.0 - 5.0 pt/100 gal	foliar spray	300 (30%)	12,000
Bacillus thuringiensis	Dipel	1.0 - 2.0 qt/100 gal	drench	600 (60%)	3,000
Kinoprene	Enstar		foliar spray	200 (20%)	10
Resmethrin			foliar spray	200 (20%)	10
Pyrethrins	Pyrenone	6 - 12 oz/acre	foliar spray	200 (20%)	100
Bifenthrin	Talstar 10W	1.0 - 3.2 oz/10 gal	foliar spray	200 (20%)	250

Table 32. Pesticides Use Estimates for Oregon Field Trees and Shrub Crops, 1992. 21,000 acres.

Common Name	Trade Name	Formulated Rate of Application	Normal Method of Application	Acres Treated	Pounds Applied a.i.
WEED CONTROL - Fall					
>>>>>>>bindweed, quackgrass, nutsedge, groundsel, shepherdspurse, bittercress, nightshade, annual bluegrass, dog fennel, redstem filaree, Canada thistle, clover					
Oxyfluorfen +	Ornamental Herbicide II		granular	1,100 (05%)	2,100
Pendimethalin		2.0 lb + 1.0 lb a.i./acre			1,100
Oxyfluorfen +	Rout		granular	1,100 (05%)	2,100
Oryzalin		2.0 lb + 1.0 lb a.i./acre			1,100
Simazine	Princep, Simazine	1.0 - 4.0 lb/acre	broadcast, band	2,100 (10%)	1,300
Napropamide	Devrinol 50DF	4.0 lb/acre	broadcast, band	5,300 (25%)	11,000
Oxyfluorfen	Goal 1.6E	5.0 - 8.0 pt/acre	broadcast, band	1,100 (05%)	1,400
Oryzalin	Surflan	1.0 - 4.0 qt/acre	broadcast, band	6,300 (30%)	7,900
Oxadiazon	Ronstar WP	4.0 - 8.0 lb a.i./acre	broadcast, band	3,200 (15%)	9,500
Isoxaben	Gallery 75DF	0.33 - 1.33 lb/acre	broadcast, band	2,100 (10%)	780
Metolachlor	Pennant	2.0 - 3.0 qt/acre	broadcast, band	1,100 (05%)	1,300
Paraquat	Gramoxone	1.0 qt/acre	spot spray	1,100 (05%)	100
Glyphosate	Roundup	1.0 qt/acre	spot spray	1,100 (05%)	100
Clopyralid	Stinger	0.5 - 1.0 pt/acre	spot spray	1,100 (05%)	50
Sethoxydim	Vantage	0.5 - 1.5 pt/acre	spot spray	1,100 (05%)	200
Dichlobenil	Casoron 4G, Norosac	100 lb/acre	granular	1,100 (05%)	4,200
SOIL FUMIGATION					
>>>>>>>weed seed, soil-borne insects, diseases (*Phytophthora*, *Verticillium*)					
Methyl bromide +		200 - 250 lb/acre	fumigate	400 (03%)	90,000
Chloropicrin			fumigate	400 (03%)	1,800
Metam-sodium	Vapam	50 - 100 gal/acre	fumigate	50 (0.2%)	12,000
IRRIGATION HOLDING PONDS					
>>>>>>>pathogens, algae					
Chlorine			water treatment	—NA—	
Bromine	Agri-Brome	5 - 10 ppm	water treatment	—NA—	
DISEASES					
>>>>>>>scab, brown rot, *Pseudomonas*, *Fusarium*, canker, *Botrytis*, crown gall, *Phytophthora*, anthracnose					
Copper	Kocide 101, Champ	1.0 lb/100 gal	foliar	6,300 (30%)	6,300
Triadimefon	Bayleton 50W	2.0 oz/100 gal	foliar	1,100 (05%)	70
Chlorothalonil	Daconil 2787 WDG	1.25 lb/100 gal	foliar	2,100 (10%)	2,100
Dodine	Syllit	0.25 - 0.5 lb/100 gal	foliar	630 (03%)	300
Mancozeb	Manzate, Fore	1.0 - 3.0 lb/acre	foliar	2,100 (10%)	2,200
Metalaxyl	Subdue 2E	1.0 - 4.0 fl oz/100 gal	drench	3,200 (15%)	120
Fosetyl-Al	Chipco Aliette	6.4 - 12.8 oz/100 gal	drench	3,200 (15%)	270
Streptomycin sulfate	Agri Strep	0.5 lb/100 gal	foliar	1,100 (05%)	330
Thiophanate-methyl	Cleary 3336	1.0 lb/acre	foliar	1,100 (05%)	1,100
Propionazole	Banner	5 - 10 fl oz/100 gal	foliar	420 (02%)	30
Fenarimol	Rubigan	8 - 12 fl oz/acre	foliar	420 (02%)	30

Table 32. Continued.

Common Name	Trade Name	Formulated Rate of Application	Normal Method of Application	Acres Treated	Pounds Applied a.i.
INSECTS					
>>>>>>> aphids, leafrollers, mites, lygus, scale, leafminers, weevils, midges, moths, symphylans					
Acephate	Orthene 75S	1.25 lb/acre	foliar	5,300 (25%)	5,300
Chlorpyrifos	Pageant DF	2.0 lb/acre	foliar	5,300 (25%)	5,300
Bifenthrin	Talstar	1.0 - 2.0 lb a.i./100 gal	foliar	2,100 (10%)	3,200
Oxythioquinox	Morestan 4L	0.5 - 1.0 lb/100 gal	foliar	2,100 (10%)	790
Oxydemeton-methyl	Metasystox-R	1.0 - 2.0 pt/acre	foliar	420 (02%)	160
Diazinon	Diazinon 50W	1.0 - 2.0 lb/acre	foliar	3,200 (15%)	2,400
Oil		1.0 gal/100 gal	foliar	3,200 (15%)	19,000
Fenbutatin-oxide	Vendex 50W	8 - 16 oz/100 gal	foliar	1,100 (05%)	390
Propargite	Ornamite	1.5 lb/acre	foliar	2,100 (10%)	950
Fonofos	Dyfonate 4E	2.0 qt/acre	soil	1,100 (05%)	2,100
Dimethoate	Dimethoate 267	1.0 pt/acre	foliar	420 (02%)	140

Table 33. Pesticides Use Estimates for Oregon Cut Flowers, 1992. 500 acres.

Common Name	Trade Name	Formulated Rate of Application	Normal Method of Application	Acres Treated	Pounds Applied a.i.
WEED CONTROL					
>>>>>>>grasses, prickly lettuce, mustard, thistle, vetch, bedstraw, briars					
Glyphosate	Roundup	1.0 qt/acre	banded	300 (60%)	100
Sethoxydim	Vantage		spot spray	50 (10%)	20
Fluazifop-butyl	Fusilade		spot spray	25 (05%)	10
DISEASES					
>>>>>>>*Pseudomonas*, *Phytophthora*, *Pseudonectria*, mildew, brown rot, anthracnose, root rots, rust					
Copper	Kocide 101, Champ	1.0 lb/100 gal	foliar	350 (70%)	1,400
Oxycarboxin	Plantvax		foliar	25 (05%)	10
Dodemorph acephate	Milban	32 fl oz/100 gal	foliar	100 (20%)	100
Mancozeb	Fore	1.0 - 3.0 lbs/acre	foliar	50 (10%)	80
Metalaxyl	Subdue 2E	1.0 - 4.0 fl oz/100 gal	drench	50 (10%)	10
Streptomycin sulfate	Agri Strep	0.5 lb/100 gal	foliar	100 (20%)	70
Thiophanate-methyl	Cleary 3336	1.0 lb/acre	foliar	50 (10%)	40
Vinclozolin	Ornalin	0.25 - 0.5 lb/acre	foliar	50 (10%)	25
INSECTS					
>>>>>>>spider mites, thrips, aphids, scale, lepidopterous larvae					
Acephate	Orthene 75S	1.25 lbs/acre	foliar	50 (10%)	50
Lime sulfur		3.0 gal/100 gal	foliar	100 (20%)	900
Oil		1.0 gal/100 gal	foliar	100 (20%)	600
Naled	Dibrom 8	1.0 oz/10,000 cu ft	vapor treatment	25 (05%)	500
Bifenthrin	Talstar	1.0 - 2.0 lb a.i./100 gal	foliar	25 (05%)	40
Dienochlor	Pentac L		foliar	50 (10%)	20
Oxydemeton-methyl	Metasystox-R	1.0 - 2.0 pt/acre	foliar	25 (05%)	10

Table 34. Pesticides Use Estimates for Oregon Ornamental Bulbs, 1992. 1,500 acres.

Common Name	Trade Name	Formulated Rate of Application	Normal Method of Application	Acres Treated	Pounds Applied a.i.
WEED CONTROL					
>>>>>>>annual ryegrass, shepherdspurse, brassicas, dog fennel, clover, dock, corn spurry, knotweed, groundsel, pineapple weed, volunteer wheat					
Diuron	Direx	1.0 - 3.0 lb/acre	broadcast	300 (30%)	500
Napropamide	Devrinol 50DF	2.0 lb/acre	broadcast	800 (80%)	1,600
Simazine	Princep, Simazine	2.0 - 4.0 lb/acre	broadcast	500 (50%)	750
Paraquat	Gramoxone	1.0 - 1.5 qt/acre	broadcast	50 (05%)	60
Glyphosate	Roundup	1.0 qt/acre	spot spray	600 (60%)	300
SOIL FUMIGATION					
>>>>>>>nematodes					
Methyl bromide		30 - 60 gal/acre	fumigate	50 (05%)	15,000
1,3-dichloropropene	Telone II	40 - 60 gal/acre	fumigate	250 (25%)	20,000
Metam-sodium	Vapam	40 gal/acre	in furrow	4 (0.4%)	480
DISEASES					
>>>>>>>*Botrytis*, mustard seed mold, fire blight, viruses, *Rhizoctonia*, *Fusarium*, *Pythium*, *Pseudomonas*, leaf spot					
Copper	Kocide 101, Champ	1.0 - 5.0 lb/acre	foliar	300 (30%)	15,000
Copper + lime	Bordeaux	10-10-100	foliar	300 (30%)	3,000
Benomyl	Benlate 50W	1.0 - 2.0 lb/100 gal	foliar or dip	500 (50%)	1,500
Thiabendazole	Mertect 340-F	30 oz/100 gal	dip	50 (05%)	200
Iprodione	Chipco 26019	2.0 lb/acre	foliar	400 (40%)	400
Mancozeb	Fore, Manzate 200	2.0 lb/100 gal	foliar	400 (40%)	400
PCNB	Terrachlor	6.0 lb/100 gal	furrow or dip	300 (30%)	1,000
Etridazole +	Banrot 20W	1.0 lb/100 gal	dip	300 (30%)	270
Thiophanate-methyl				300 (30%)	450
Thiram			bulb coat	300 (30%)	100
Triadimefon	Bayleton 50W	2.0 - 4.0 oz/acre	foliar	500 (50%)	60
Chlorothalonil	Daconil 2787	2.0 - 3.0 pt/100 gal	foliar or dip	800 (80%)	1,000
Thiophanate-methyl	Cleary 3336	1.0 - 2.0 lb/100 gal	foliar or dip	50 (05%)	200
INSECTS					
>>>>>>>aphids, narcissus bulb fly					
Acephate	Orthene 75S	0.75 - 1.0 lb/acre	foliar	50 (05%)	50
Oil		1.0 - 3.0 gal/100	foliar	50 (05%)	90
Trichlorfon	Proxol 80SP	2.0 lb/10 gal/100 ft	drench	100 (10%)	23,000
Oxycarboxin	Vitavax 3		dip	100 (10%)	100
Fenamiphos	Nemacur 15	100 lb/acre	granule	400 (40%)	280
Chlorpyrifos	Pageant DF	0.5 - 1.0 qt/acre	foliar	50 (05%)	50
Diazinon	AG500	0.5 - 1.0 qt/acre	foliar	50 (05%)	50
Carbofuran	Furadan	1.0 - 5.0 qt/acre	foliar	200 (20%)	500
Disulfoton	Di-Syston	1.0 - 5.0 qt/acre	foliar	200 (20%)	500
Carbaryl		1.0 - 2.0 lb/acre	foliar	50 (05%)	50
Dimethoate	Dimethoate 267	1.0 - 2.0 qt/acre	foliar	1000 (100%)	1,000
PLANT GROWTH REGULATORS					
>>>>>>>bud removal					
CIPC	Sprout Nip	4.0 qt/acre	foliar	300 (30%)	900

Extension Service, Oregon State University, Corvallis, O.E. Smith, director. This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties.