STATION BULLETIN 382 DECEMBER 1940

Cause and Control of the Coryneum Blight of Oriental Arborvitae

J. A. MILBRATH and F. P. MCWHORTER

Oregon State System of Higher Education
Agricultural Experiment Station
Oregon State College
Corvallis

SUMMARY OF CONTROL

1. If the arborvitae are diseased with Coryneum blight, prune out the diseased foliage during early summer.

2. Spray the diseased plants in the early fall before the cold rainy season to prevent new infections.

3. Spray apparently healthy plants in the early fall to prevent their becoming diseased.

4. Spray both healthy and diseased plants with either red copper oxide spray or tribasic copper sulphate spray. One application in the early fall is sufficient for healthy plants but a second application is advised for diseased plants.

Cause and Control of the Coryneum Blight of Oriental Arborvitae

By

J. A. MILBRATH, Assistant Pathologist

and

F. P. MCWHORTER, Plant Pathologist

THE occurrence of "Berckmans Blight," a foliage disease of the oriental arborvitae, can be traced as far back as 1930. Since then it has become prevalent and serious in western Oregon and Washington, where the wet fall and winter seasons are particularly conducive to its development. The disease had become by 1936 a limiting factor in the production of saleable "Berckmans" and a source of frequent disappointment to home owners who had used these shrubs to accent their yard plantings. Investigation of this disease began in 1937 at the Oregon Experiment Station. Suggestions for control based on this investigation were issued in 1938 and a technical paper on the disease was published in 1940.* The application of control measures developed during this investigation has been so successful that continued production in nurseries is assured, and it is feasible to recommend oriental arborvitae as ideal plants for Northwest use. This bulletin is intended to bring up to date the recommendations, which have been evaluated by several years trial.

The original source of this disease is unknown. The oriental arborvitae was introduced from the orient into European gardens about 1752. Since then many horticultural varieties have been developed and distributed throughout the world. The very popular variety of golden arborvitae known as Berckmans, which is particularly susceptible to the disease, is comparatively new. During the same period in which this arborvitae blight has developed, a related disease has appeared on the Monterey cypress in California. The causal fungi may have migrated to their new hosts from plants where they were inconspicuous and undetected.

The cause of Berckmans blight. The blight is not due to cold injury, improper watering, sunburn, or any climatic factor, but to infection by a specific fungus. This fungus has proved to be a species different from any previously described and has been named *Coryneum berckmanii*. The species belongs to a group characterized by the development of reproductive bodies called spores, each of which has five inner walls or partitions. It is not an obligate parasite, capable of growth only on a living host, but can be grown on culture media within glass plates or test tubes. This circumstance has enabled us to observe its growth requirements and to compare it with the Coryneum that causes the blight of Monterey cypress, a very serious disease in California. The two fungi both bear five partitioned spores, but they are distinct since they grow differently on culture media and their spores differ in size. The Monterey disease is the more difficult to control because its causal fungus becomes systemic within large branches where it cannot be reached by sprays.

* Milbrath, J. A. Coryneum blight of oriental arborvitae caused by *Coryneum berckmanii*. Phytopath.30:592-602, 1940.

Studies of the Coryneum fungus that causes Berckmans blight have shown that it thrives and grows best at temperatures around 50° F. A certain amount of moisture must be present to insure growth and prevent the fungus from remaining in a resting stage. These circumstances are in agreement with the observation that the fungus fruits during all the cold months, infects during the wet fall months, and is an active parasite during the winter. The symptoms by which the disease is recognized develop coincidently with the growth of the Coryneum fungus in the young foliage. Because of this relationship the proper and distinctive name for the disease is Coryneum Blight. The spores of the fungus are too tiny to be seen with the unaided eye but the black specks (acervuli) in which they are borne can be seen on the gray foliage, a circumstance that aids one in distinguishing this disease from other diseases of arborvitae. (See Figure 1.) Every one of these black specks may contain more than 1,000 spores, each of which is capable of reproducing the disease.

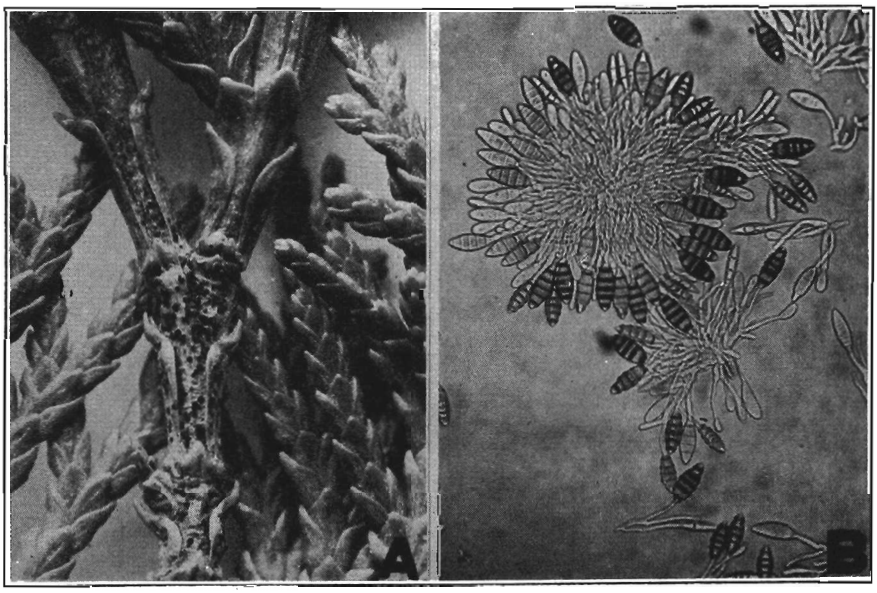

Figure 1. *A*. The tiny specks on the branchlet show the appearance of the fruiting bodies of the fungus when magnified three times. *B*. The appearance of a small portion of one of these fruiting bodies when magnified 200 times. Observe the spores, which are spindle-shaped and five-partitioned.

How to recognize the disease. The young tender foliage being very susceptible, infections begin at the tips of the branches and develop downward. When the foliage is invaded by this fungus, it changes from the normal green and assumes a grayish cast. In order that the disease may be stopped before much damage has been done, it is desirable to recognize these early symptoms. As the fungus moves down the small branchlets to the larger branchlets, some of the latter become girdled and the foliage beyond these injuries then changes from the normal green to a reddish brown. This brown discoloration is especial-

ly conspicuous in the spring when the warm weather begins to dry out the foliage above the zones where the branches are girdled. Eventually, much of the infected foliage falls and exposes unsightly masses of gray stems. The tiny black fruiting bodies of the causal fungus may be found on infected gray foliage, especially at the positions where the branchlets are girdled. (See Figure 1A.) Microscopical examination of these for typical spores permits positive diagnosis of the disease.

When Berckmans or other oriental arborvitae growing in western Oregon or Washington develop brown areas in the outer foliage, or appear dead at the tops, the trouble is almost certain to be due to the Coryneum fungus. This browning is distinct from the discoloration of inner leaves within large plants, which results from shading and not from disease. The blights of these plants in other parts of the United States are usually due to other fungi and are not amenable to the control herein recommended. The disease requires a special climate for its inception and continuance and is not likely to be of importance outside of this climatic zone. Its distribution is very narrow even in Oregon and Washington. The true Coryneum blight is a foliage disease, being confined to the imbricated or bractlike leaves and small twigs. Large woody stems are not attacked, but infected plants eventually die because of continued defoliation.

Plants susceptible to Coryneum blight. The arborvitae commonly called Berckmans is a variety of the *orientalis* species of *Thuja*. Botanically speaking, its proper name is *Thuja orientalis* L. var. *conspicua* Berckmans. The species *orientalis* comprises many varieties, which include the golden arborvitae and several green forms of delightful globular or pyramidal habits. Unfortunately, most if not all of these are susceptible to Coryneum blight, natural infections having been observed on the varieties *conspicua, beverleyensis, elegantissima, compacta,* and *stricta.* The effect of the fungus on all of these is essentially like that described for Berckmans. Fortunately, American and European species seem to be immune. The only other species of plant known to be susceptible to this blight is the Italian cypress, *Cupressus sempervirens.* A few of these cypress have been observed naturally infected, but the disease is of greatest economic importance on the golden arborvitae.

How the disease progresses. An understanding of how a disease oversummers or overwinters, infects, and progresses is essential for effective control. The activities of disease-causing fungi are usually related to external conditions such as rains, temperature, condition of the host, and many other factors. For this reason fungus injury is often mistaken for weather injury. The Coryneum fungus that causes this blight has a simple life history but it is very greatly influenced by seasonal conditions. It first produces a vegetative stage, which spreads within the scale leaves, and later a sporulation stage, which develops on small branchlets. Let us follow the story of a mildly diseased plant growing among healthy neighbors.

During the summer the browned tips of the shoots will dry up. Some green foliage on neighboring branches will grow beyond and tend to cover up the injured member but the Coryneum fungus remains dormant until the cold rains of early fall begin to rejuvenate its vegetative body within the last infected foliage.* During an average year the fungus begins to form a crop of spores

* A possible exception of this is the condition in home gardens where oriental arborvitae are frequently sprayed with cold water in the afternoons and evenings during late summer. New infections might be initiated by this watering and require a special spray program.

about the last of November. These are washed and splashed by rains to new locations within the plant's foliage, where they set up new infections. These become noticeably diseased areas during the winter months. The spores are very small and can be easily carried by insects or by air currents from shrub to shrub. When they find a resting place on young foliage and are later exposed to cold and moisture, infection may readily ensue and another plant become a victim of Coryneum blight. As the dryer part of the season approaches, the symptoms of the disease become more and more apparent but the real damage was done during the wet months. Severe damage is a composite of many separate infections. The fungus does not spread for relatively long distances along woody stems or grow from shrub to shrub. The essential point of control, therefore, is the prevention of these infections that begin in the fall of the year.

Principles of control. Control of Coryneum blight involves two considerations; (1) the curing of diseased plants, especially in home plantings, and (2) keeping healthy plants healthy. The curing of a diseased plant is accomplished by pruning out diseased parts and spraying the uninfected parts. Keeping plants healthy involves applying a protective spray at least once a year and watching for first symptoms of the disease. Spraying must be done at a time that will prevent fall infection.

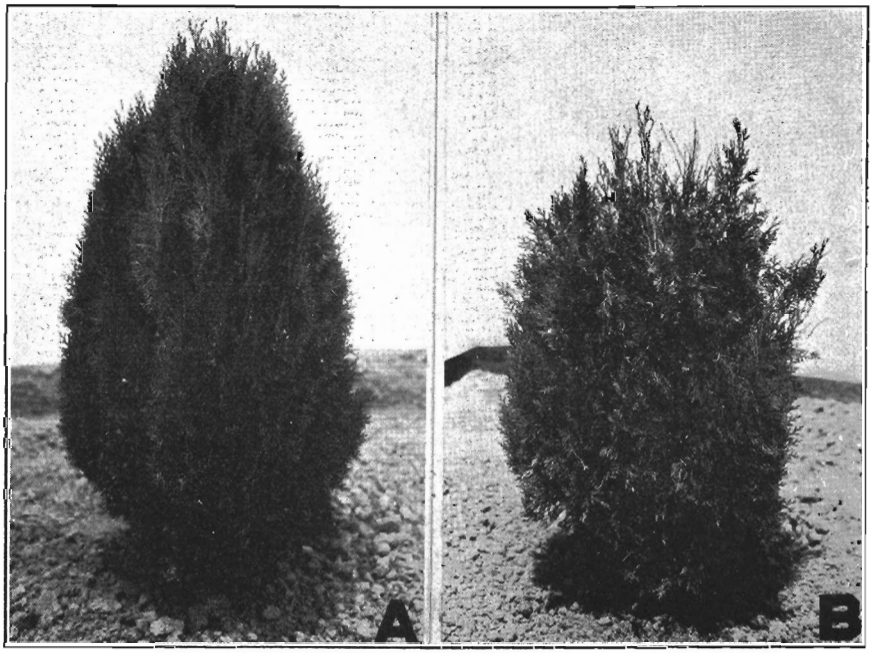

Figure 2. Comparison of sprayed and nonsprayed trees. Both trees were severely infected at the beginning of the treatment. *A*. Tree protected by a copper spray. *B*. Tree left unsprayed for a check.

How to treat a diseased plant. A plant that is not more than one-third dead may be saved and brought to a good state of health. The brown and gray branches should be cut out below the discolored areas. This should be done in the late spring or early summer. The debris that accumulates in large plants should be cleaned out when the pruning is done. The pruning should be planned to permit the remaining healthy foliage to grow into a pleasing shape.

The spraying of arborvitae in the fall before infections set in is the point to stress whether or not the plants appear diseased. Pruning alone will not suffice, since it is likely that spores from the preceding spring are scattered about the healthy parts of the plant and are waiting for the cold fall rains to provide conditions for new infections. Either of the copper sprays described below are advised for curing diseased plants as well as for protecting healthy ones.

Sprays that have been tested. Home growers and others are advised not to experiment with miscellaneous sprays or dusts to control this Coryneum blight. The arborvitae plants will not tolerate some, many are useless against the fungus, and only a few are really specific. More than thirty sprays and combinations have been tested on the plantings of diseased arborvitae at the Oregon Experiment Station and in cooperating nurseries.* These included bordeaux (copper sulphate and lime), burgundy mixture, red copper oxide, yellow copper oxide, basic copper sulphate, copper oxalate, copper phosphate, copper oxychloride, organic mercuries, sulphur dusts and sulphur-resin sprays, lime sulphur, dye applications, and combinations of these with various wetting agents including Penetrol. Some of these chemicals are marketed under special trade names such as Basi-cop, Cuprocide, Sulreso, Coposil, etc. The sprays showing promise have been tried at different times of the year to determine when they should be applied and how many applications are necessary.

Injury to and discoloration of the host plants were chief considerations in choosing sprays to use. Lime sulphur and Sulreso (a sulphur-resin combination originally developed for control of Botrytis or fire of bulbous plants) cause severe burn and cannot be used. Alkaline burgundy mixture is colorless and theoretically desirable but it cannot be used since it also causes severe burn. Bordeaux mixture composed of four parts of copper sulphate (blue vitriol) to four parts of lime and 100 gallons of water is unsatisfactory because it leaves an objectionable residue on the foliage and gives inconsistent control. Copper oxychloride gives insufficient control against this Coryneum blight. The dye, Malachite Green, is harmless to the plants and may have a special use as a color-improving antiseptic spray for home plantings, but its use is not generally advisable. Outstanding control over a 3-year period of test was obtained from red copper oxide and basic copper sulphate. A general summary of the more important sprays is given in Table 1.

Sprays recommended and how to make them up. The two copper materials recommended for preparing sprays for both commercial nurseries and home gardens are red copper oxide and basic copper sulphate. Either one of these copper compounds will control the disease if properly used, but only one of them should be used at a time and on the same plant during a season. Each of these chemicals must be of the right type and consistency for spray

* Thanks are due to several nurserymen who have furnished arborvitae plants for the many tests carried out at Corvallis and who have permitted us to take records on the effect of commercial spray applications in nurseries.

Table 1. COMPARATIVE EFFICIENCY RATING OF SPRAYS

Sprays injurious to arborvitae	Sprays that do not control the disease	Sprays that show good control or promise of control
Alkaline Burgundy	Lime-sulphur	Tribasic copper sulphate
Lime-sulphur	Sulreso	Red copper oxide
Sulreso	Sulphur dusts	Copper ammonium silicate
	Copper oxychloride	Copper oxalate
	Copper phosphate	
	Cuprocide 54Y (Yellow copper oxide)	
	Bordeaux	

The grouping of the above sprays is based on a study of their effect on severely diseased plants. The efficiency of some of these as protective sprays for healthy plants would be higher than the curative value given above for diseased plants.

Table 2. SUMMARY BY YEARS OF CERTAIN FUNGICIDES TESTED FOR CONTROL OF BERCKMANS BLIGHT

Treatment and year	Number of plants tested	Number of plants clean	Number of plants with trace of infection	Number of plants with scattered infection	Number of plants with heavy infection	Degree of infection
						Per cent
Basic copper sulphate						
1937	23	5	18	0	0	0.0
1938	252	180	71	1	0	0.4
1939	145	111	27	4	3	4.8
Total	420	296	116	5	3	1.9
Red copper oxide						
1937	39	12	27	0	0	0.0
1938	289	172	106	11	0	3.8
1939	183	110	66	2	5	3.7
Total	511	294	199	13	5	3.5
Copper silicate 6-100						
1938	11	10	1	0	0	0.0
1939	43	29	12	1	1	4.6
Total	54	39	13	1	1	3.7
Copper phosphate 1-50						
1937	4	4	0	0	0	0.0
1938	10	6	2	1	1	20.0
Total	14	10	2	1	1	14.4
Copper oxychloride 6-100						
1937	5	0	2	3	0	60.0
1938	11	8	1	2	0	18.1
1939	31	16	13	0	2	6.4
Total	47	24	16	5	2	14.8
Bordeaux 4-4-50						
1937	47	16	30	1	0	2.1
1938	151	28	70	46	7	35.0
1939	146	45	65	29	7	24.6
Total	344	89	165	76	14	26.1
Unsprayed check trees						
1937	23	1	0	7	15	95.7
1938	208	0	7	56	145	96.6
1939	82	3	15	12	52	78.0
Total	313	4	22	75	212	91.7

Trace of infection denotes that the disease was satisfactorily checked but one to three small branchlets had become infected without any secondary spread; scattered infection indicates three or more infection centers with some secondary spread; heavily infected indicates no control and often as much as 50 to 75 per cent of the foliage blighted. For comparison, the degree of infection is calculated as percentage of plants with scattered and heavy infection.

purposes. The red copper oxide must be very finely powdered. This finely powdered type is manufactured for spray purposes or seed treatments, the same material being usable for both. Several spray materials are referred to as basic copper sulphate. The kind we recommend for arborvitae is the *Tribasic* type. Ordinary copper sulphate or blue vitriol is entirely different from either the red copper oxide or the basic copper sulphate, and cannot be used.

The methods of preparing these two copper sprays are identical. A wetting agent or spreader of the detergent type must be used with each of them. Several brands and kinds of detergents are satisfactory, but since they differ in wetting ability, different amounts of each have to be used as directed by the manufacturer. The rule is to mix into the spray the smallest amount of the wetting agent necessary to wet the foliage thoroughly.* In most of our tests we used Vatsol O. S. Representative formulae for Vatsol O. S. are therefore given in the tables. The basic formulas recommended are as follows: For making the red copper oxide spray, use spreader (Vatsol) ½ pound, red copper oxide 2 pounds, water 100 gallons. For making the basic copper sulphate spray, use spreader ½ pound, tribasic copper sulphate 4 pounds, water 100 gallons. The equivalent amounts of materials to use when mixing small units are shown in Table 3.

Certain precautions are necessary to make up a good spray. These are as follows:

1. Make up the spreader (wetting agent or detergent) first.

2. Never pour water on the spreader but pour the spreader slowly into the water and stir at the same time. Spreaders of the detergent type are sold in dust form and will cake if water is poured on them.

3. When mixing large amounts of spray, it is convenient to mix the spreader in a small volume of water by pouring it into the water and stirring with a stick or egg beater until it is well mixed. Then pour this mixture into the water in the spray tank.

4. After the spreader is dissolved in the tank, add the copper material slowly. Stir vigorously.

5. Since these copper compounds are insoluble in water, they must be kept in suspension by means of vigorous agitation during the actual spray application. Power sprayers accomplish this by means of propellers within the tank. If a barrel sprayer is used, the mixture must be stirred with a stick or churned with a hoe at frequent intervals. The mixture in a hand sprayer can be shaken by turning the tank "end for end" after each pumping up of air.

6. Copper sprays of this type are more efficient if used immediately after they are made up. If they are allowed to settle out, it is difficult to get them back into the state of colloidal suspension required for effective spraying.

* The manufacturers may offer these spray materials with these wetting agents already mixed into them. The amount of these preparations to use can be determined in terms of copper content. The copper oxide contains 96 per cent copper and the tribasic copper sulphate 53 per cent. The amount of ready-mixed material to use can be worked out by proportion so that it will correspond to the amount of chemical recommended. Thus, if a ready-mixed copper oxide contains 48 per cent copper, one should use 4 pounds to the 100 gallons of water. Oregon Experiment Station Bulletin 336 presents data on how to mix sprays.

If the sprays are made up correctly, they will spread evenly, wet the plant evenly, and leave little noticeable residue. One who is accustomed to spraying with bordeaux may feel disappointed when he first tries these "colloidal coppers" since they leave so little evidence of coverage, although the copper is spread over the foliage in an inconspicuous but effective form. The arborvitae is not disfigured or discolored by the application of either of these sprays and improvement in general appearance should be noticed during the winter months.

Table 3. AMOUNTS OF MATERIALS TO USE TO MAKE UP EITHER THE RED COPPER OXIDE SPRAY OR THE TRIBASIC COPPER SULPHATE SPRAY

Detergent or wetting agent	Red copper oxide	—or— Tribasic copper sulphate	Amount of spray
½ pound	2 pounds	4 pounds	100 gallons
4 ounces	1 pound	2 pounds	50 gallons
2 ounces	8 ounces	1 pound	25 gallons
22 grams 9 tsp.	90 grams 6 tbs.	180 grams 11 tbs.	10 gallons
11 grams 4½ tsp.	45 grams 6¼ tsp.	90 grams 6 tbs.	5 gallons
6 grams 2¼ tsp.	27 grams 3¾ tsp.	54 grams 7½ tsp.	3 gallons
2 grams ¾ tsp.	9 grams 1½ tsp.	18 grams 2½ tsp.	1 gallon

EXPLANATION: Use either red copper oxide or tribasic copper sulphate to make up a spray. Do not use both in the same spray.
tsp. = teaspoon
tbs. = tablespoon

When and how to apply sprays. The sprays must be applied to protect against the infections that start in the fall. The ideal time is just before the fall rains begin; if this time has been missed, however, an application during early winter should prove better than no spray at all. If the plant is already diseased, two applications are advised; one at the beginning of the rainy season, the other a few weeks later. The sprays should be applied when the foliage is dry and at such a time that a period of at least 6 hours will ensue, if possible, before the plants are exposed to rain. The spray must dry thoroughly in order to enable it to stick properly and remain as a protective coverage on the foliage. Midwinter or late spring sprays are not advised.

High-pressure spray equipment is not necessary for control of this disease. The plants should be thoroughly drenched with spray. This can be done effectively with a hand sprayer costing about $5.00. The use of a detergent wetting agent increases coverage at low pressures so that spraying with a hand sprayer is completely effective. It is far more important to agitate these colloidal copper spray materials thoroughly during the application than it is to apply them with high pressure.

OREGON STATE BOARD OF HIGHER EDUCATION

F. E. Callister ..... *Albany*
Beatrice Walton Sackett ..... *Marshfield*
C. A. Brand ..... *Roseburg*
E. C. Sammons ..... *Portland*
Robert W. Ruhl ..... *Medford*
Edgar William Smith ..... *Portland*
Willard L. Marks ..... *Albany*
R. C. Groesbeck ..... *Klamath Falls*
Mac Hoke ..... *Pendleton*
Frederick M. Hunter, Ed. D., LL.D. ..... Chancellor of Higher Education

STAFF OF AGRICULTURAL EXPERIMENT STATION

*Staff members marked * are United States Department of Agriculture investigators stationed in Oregon*

Frank Llewellyn Ballard, B.S. ..... President of the State College
Wm. A. Schoenfeld, B.S.A., M.B.A. ..... Director
R. S. Besse, M.S. ..... Assistant Director
Esther McKinney ..... Accountant
Margaret Hurst, B S ..... Secretary

Division of Agricultural Economics

E. L. Potter, M.S. ..... Agricultural Economist; In Charge, Division of Agricultural Economics

Agricultural Economics

W. H. Dreesen, Ph.D. ..... Agricultural Economist
D. B. DeLoach, Ph.D. ..... Associate Economist

Farm Management

D. C. Mumford, M.S. ..... Economist in Charge
G. W. Kuhlman, Ph.D. ..... Associate Economist
W. W. Gorton, M.S. ..... Assistant Economist
H. L. Thomas, M.S. ..... Associate Agricultural Economist, Conservation Economic Division, Soil Conservation.*
J. C. Moore, M.S. ..... State Representative, Division of State and Local Planning, Bureau of Agricultural Economics*
V. W. Baker, B.S. ..... Assistant Agricultural Economist, Division of Land Economics*

Division of Animal Industries

P. M. Brandt, A.M. ..... Dairy Husbandman; In Charge, Division of Animal Industries

Animal Husbandry

R. G. Johnson, B.S. ..... Animal Husbandman
O. M. Nelson, M.S. ..... Animal Husbandman
A. W. Oliver, M.S. ..... Associate Animal Husbandman
B. W. Rodenwold, M.S. ..... Assistant Animal Husbandman

Dairy Husbandry

G. H. Wilster, Ph.D. ..... Dairy Husbandman
I. R. Jones, Ph.D. ..... Dairy Husbandman
H. P. Ewalt, B.S. ..... Research Assistant (DairyHusbandry)
R. E. Stout, M.S. ..... Research Assistant (Dairy Husbandry)
V. P. Smith, B.S. ..... Research Assistant (Dairy Husbandry)

Fish and Game Management

R. E. Dimick, M.S. ..... Wildlife Conservationist in Charge
F. P. Griffiths, Ph.D. ..... Assistant Conservationist*
A. S. Einarsen, B.S. ..... Associate Biologist, Bureau of Biological Survey*
Jay B Long, B.S. ..... Research Assistant (Fish and Game Management)

Poultry Husbandry

H. E. Cosby ..... Poultry Husbandman in Charge
F. L. Knowlton, M.S. ..... Poultry Husbandman
W. T. Cooney, B.S. ..... Research Assistant (Poultry Husbandry)

Veterinary Medicine

J. N. Shaw, B.S., D.V.M. ..... Veterinarian in Charge
E. M. Dickinson, D.V.M., M.S. ..... Associate Veterinarian
O. H. Muth, D.V.M., M.S. ..... Associate Veterinarian
R. W. Dougherty, B.S., D.V.M. ..... Assistant Veterinarian
A. S. Rosenwald, B.S., D.V.M. ..... Assistant Veterinarian
Roland Scott, D.V.M. ..... Research Assistant (Veterinary Medicine)†
Richard Shuman, D.V.M. ..... Junior Veterinarian, Bureau of Animal Industries*

† On leave of absence.

STATION STAFF—(*Continued*)

Division of Plant Industries

G. R. Hyslop, B.S.—Agronomist; In Charge, Division of Plant Industries

Farm Crops

H. A. Schoth, M.S.—Agronomist; Division of Forage Crops and Diseases*
D. D. Hill, Ph.D.—Agronomist
R. E. Fore, Ph.D.—Associate Agronomist*
H. H. Rampton, M.S.—Assist. Agronomist (Division of Forage Crops and Diseases)*
L. E. Harris, M.S.—Assistant Agronomist
H. E. Finnell, M.S.—Assistant Agronomist
Elton Nelson, B.S.—Agent, Division of Cotton and Other Fiber Crops and Diseases*
Louisa A. Kanipe, B.S.—Junior Botanist, Division of Seed Investigations*
A. E. Gross, M.S.—Research Assistant (Farm Crops)
L. R. Hansen, M.S.—Research Assistant (Farm Crops)
Henry R. Fortmann, B.S.—Research Graduate Assistant (Farm Crops)

Food Industries

E. H. Wiegand, B.S.A.—Technologist in Charge
T. Onsdorff, M.S.—Associate Technologist
D. R. Mills, B.S.—Assistant Technologist
E. W. Harvey, M.S.—Research Assistant (Food Industries)

Horticulture

W. S. Brown, M.S., D.Sc.—Horticulturist
H. Hartman, M.S.—Horticulturist (Pomology)
A. G. B. Bouquet, M.S.—Horticulturist (Vegetable Crops)
C. E. Schuster, M.S.—Horticulturist (Division of Fruit and Vegetable Crops and Diseases)*
W. P. Duruz, Ph.D.—Horticulturist (Plant Propagation)†
G. F. Waldo, M.S.—Associate Pomologist (Division of Fruit and Vegetable Crops and Diseases)*
E. Hansen, M.S.—Assistant Horticulturist (Pomology)
A. N. Roberts, B.S.—Research Assistant (Horticulture)

Soil Science

W. L. Powers, Ph.D.—Soil Scientist in Charge
C. V. Ruzek, M.S.—Soil Scientist (Fertility)
M. R. Lewis, C.E.—Irrigation and Drainage Engineer, Soil Conservation*
R. E. Stephenson, Ph.D.—Soil Scientist
E. F. Torgerson, B.S.—Associate Soil Scientist (Soil Survey)
J. M. Haley, B.S.—Assistant Irrigation Engineer, Cooperative Agent, Soil Conservation Service*
A. W. Marsh, M.S.—Research Graduate Assistant (Soils)
H. E. Clark, B.S.—Research Graduate Assistant (Soils)
H. E. Dregne, M.S.—Research Graduate Assistant (Soils)

Agricultural Chemistry

J. S. Jones, M.S.A.—Chemist in Charge
R. H. Robinson, M.S.—Chemist (Insecticides and Fungicides)
J. R. Haag, Ph.D.—Chemist (Animal Nutrition)
D. E. Bullis, M.S.—Associate Chemist
M. B. Hatch, M.S.—Assistant Chemist
J. C. Lewis, M.S.—Assistant Chemist

Agricultural Engineering

F. E. Price, B.S.—Agricultural Engineer in Charge
W. M. Hurst, M.A.—Agricultural Engineer, Bureau of Agricultural Chemistry and Engineering*
H. R. Sinnard, M.S.—Associate Agricultural Engineer (Farm Structures)
C. I. Branton, B.S.—Assistant Agricultural Engineer†
G. R. Stafford—Engineering Aid, Bureau of Agricultural Chemistry and Engineering*
H. F. Carnes, B.S.—Junior Agricultural Engineer, Bureau of Agricultural Chemistry and Engineering*
L. M. Klein, B.S.—Mechanical Engineer, Bureau of Agricultural Chemistry and Engineering*

Bacteriology

G. V. Copson, M.S.—Bacteriologist in Charge
J. E. Simmons, M.S.—Associate Bacteriologist
W. B. Bollen, Ph.D.—Associate Bacteriologist
F. J. Rudert, Ph.D.—Research Assistant (Bacteriology)

Entomology

D. C. Mote, Ph.D.—Entomologist in Charge

† On leave of absence.

STATION STAFF—(Continued)

B. G. Thompson, Ph.D.....Associate Entomologist
S. C. Jones, M.S.....Assistant Entomologist
K. W. Gray, M.S.....Assistant Entomologist
H. E. Morrison, M.S.....Assistant in Entomology
Joe Schuh, M.S.....Assistant in Entomology

Home Economics

Maud M. Wilson, A.M.....Home Economist
Helen McCullough, M.A.....Assistant Home Economist

Plant Pathology

C. E. Owens, Ph.D.....Plant Pathologist in Charge
S. M. Zeller, Ph.D.....Plant Pathologist
F. P. McWhorter, Ph.D.....Plant Pathologist*
B. F. Dana, M.S.....Plant Pathologist (Division of Fruit and Vegetable Crops and Diseases)*
F. D. Bailey, M.S.....Associate Plant Pathologist (Agricultural Marketing Service)*
P. W. Miller, Ph.D.....Associate Pathologist (Division of Fruit and Vegetable Crops and Diseases)*
G. R. Hoerner, M.S.....Agent (Division of Drug and Related Plants)*
C. G. Walton, B.S.....Agent (Division of Drug and Related Plants)*
John Milbrath, Ph.D.....Assistant Plant Pathologist

Publications and News Service

C. D. Byrne, Ed.D.....Director of Information
E. T. Reed, B.S., A.B.....Editor of Publications
D. M. Goode, M.A.....Editor of Publications
J. C. Burtner, B.S.....In Charge of News Service

Branch Stations

L. Childs, A.B.....Superintendent, Hood River Branch Experiment Station, Hood River
F. C. Reimer, M.S.....Superintendent, Southern Oregon Branch Experiment Station, Talent
D. E. Richards, B.S.....Superintendent, Eastern Oregon Livestock Branch Experiment Station, Union
H. K. Dean, B.S.....Superintendent, Umatilla Branch Experiment Station (Division of Western Irrigation Agriculture), Hermiston*
Obil Shattuck, M.S.....Superintendent, Harney Branch Experiment Station, Burns
H. B. Howell, B.S.....Superintendent, John Jacob Astor Branch Experiment Station, Astoria
Arch Work, B.S.....Associate Irrigation Engineer (Division of Irrigation), Medford*
G. A. Mitchell, B.S.....Superintendent, Pendleton Branch Station (Dry Land Agriculture), Pendleton*
K. B. Platt, M.S.....Superintendent and Assistant Range Examiner (Division of Grazing), Squaw Butte Range Experiment Station, Burns*
R. G. Johnson, B.S.....Leader of Livestock Research Projects, Squaw Butte Range Experiment Station, Burns
M. M. Oveson, M.S.....Superintendent, Sherman Branch Experiment Station, Moro*
E. S. Degman, Ph.D.....Superintendent and Associate Pomologist, (Division of Fruit and Vegetable Crops and Diseases), Medford*
G. G. Brown, A.B., B.S.....Horticulturist, Hood River Branch Experiment Station, Hood River
L. G. Gentner, M.S.....Associate Entomologist, Southern Oregon Branch Experiment Station, Talent
J. F. Martin, M.S.....Assistant Agronomist (Division of Cereal Crops and Diseases), Pendleton*
R. E. Hutchison, M.S.....Assistant Superintendent, Harney Branch Experiment Station, Burns
Bruce Allyn, B.S.....Junior Irrigation Engineer (Division of Fruit and Vegetable Crops and Diseases), Medford*
J. R. Kienholz, Ph.D.....Junior Pathologist (Division of Fruit and Vegetable Crops and Diseases), Hood River*
R. W. Henderson, B.S.....Research Assistant, Sherman Branch Experiment Station, Moro
R. D. Frichtel, B.S.....Junior Range Examiner (Division of Grazing), Squaw Butte Range Experiment Station, Burns*
Joseph Belanger, B.S.....Cooperative Research Agent, Conservation Experiment Station (Division of Soil Conservation), Moro*