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TENTH ANNUAL  
WESTERN WEED CONTROL CONFERENCE

Silver Room  
Odd Fellows Temple  
Sacramento, California  
February 2 & 4, 1948

College of Agriculture  
University of California  
Davis, California  
February 3, 1948

Virgil Freed, President

- - - - -

The 10th annual Western Weed Control Conference was called to order by President Freed at 10:30 A.M., February 2, 1948, in the Silver Room of the Odd Fellows Temple, Sacramento, California.

The president called for roll call of State Officials. The following were represented:

Arizona	Howard P. Cords
California	Walter S. Ball
Colorado	Bruce J. Thornton
Idaho	V. A. Cox
Montana	H. E. Morris
Nevada	Lee Burge
New Mexico	No official representative
Oregon	Virgil Freed
Utah	George Hobson
Washington	W. C. McMinimee
Wyoming	George B. Harston
Hawaii	Dr. Francis Hance
Canada	No official representative

It was estimated that over 500 persons attended these meetings although only 401 registered from 21 states, Washington, D.C., Hawaii, and Canada.

## REGISTRATION

### ARIZONA

Howard P. Cords	Agronomy Department, University of Arizona, Tuscon
George E. Glendening	Southwestern Forestand Range Experiment Station, Tuscon
F. B. Harbour	Tovrea's Fertilizer and Insecticide Division, 2834 North 24th Place, Phoenix
M. B. Irvine	Dow Chemical Company, 4727 North 6th Street, Phoenix
L. S. Madsen	Southwestern Co op Wholesale, 1206 East Pierce Street, Phoenix
Lloyd E. Norris	United Producers and Consumers Co-op, 544 East Adams, Phoenix
Ken W. Parker	Southwestern Forest and Range Experiment Station, 2900 East 9th Street, Tuscon

### CALIFORNIA

H. E. Adams	Santa Fe Railway Company, Fresno
Norman B. Akesson	Division of Agricultural Engineering, University of California, Davis
L. E. Anderson	Ferry Morse Seed Company, 765 Middle Road, Belmont
Eugene H. Armstrong	Gring Pest Control, 3015 Shattuck Avenue, Berkeley
Joseph Arrigoni	Fabricated Metals, 900 - 33rd Avenue, Oakland 1
H. W. Arrowsmith	American Cyanamid Company, 2091 Webster Street, Palo Alto
H. L. Atwood	Atwood Crop Dusters, 236 Geil Street, Salinas
W. E. Ball	Stauffer Chemical Company, 20 Wilson Street, San Rafael
Walter S. Ball	State Department of Agriculture, Sacramento
C. S. Banta	Banta and Driscoll, 715 North Chester, Los Angeles
Payl P. Baranek	Bureau of Reclamation, PO Box D, Courtland
Monte J. Bauer	Rt. 1, Box 374-B, Santa Ana
Ralph R. Beck	American Cyanamid Company, 5626 Ocean View Drive, Oakland 18
John M. Bell	California Research Corporation, Richmond
H. J. Bensinger	American Potash and Chemical Corporation, 141 West Santa Barbara Street, Los Angeles
Lester J. Berry	Agricultural Extension Service, Redding
Richard R. Berve	R. L. Berve Tractor Company, 49 South Aurora Street, Stockton
E. W. Bodine	Shell Oil Company, 100 Bush Street, San Francisco
Almer L. Borges	Airplane Crop Dusters, Airport, Clarksburg
A. E. Botsford	John Deere Plow Company, 651 Brannan Street, San Francisco
B. B. Boyer	Cloroben Corporation, 6063 Colgate Avenue, Los Angeles
F. W. Brady	Hypro Engineering Company, 557 Orange, Los Altos
Gene E. Brendlin	Brendlin Ranch Company, 267 Pismo Street, San Luis Obispo
R. N. Brookins	Essick Manufacturing Company, 1950 Santa Fe Avenue, Los Angeles 21
Gary T. Brown	Colloidal Products Corporation, 2598 Taylor, San Francisco
John C. Brownwell	Ralston Purina Company, PO Box 359, Brawley
Emro C. Bruch	State Department of Agriculture, Sacramento
C. D. Bundesen	M. Vonsen Company, 736 H Street, Petaluma
Edward W. Bushing	Paramount Pest Control, 1325 Nebraska Street, Vallejo
C. C. Byer	General Petroleum Corporation, 1800 Skyline Drive, Puente
Eugene G. Cakin	J-3, Aggie Villa, University of California, Davis
R. S. Campbell	California Orchard Heater Company, 1539 Ganesha Place, Pomona
E. M. Chauvaud	Rohm and Haas Company, 1405 North 9th St., Santa Ana
E. H. Coe	Julius Hyman Company, 9 Main Street, San Francisco
O. T. Coffin	Swift and Company, 612 - 9th Street, Los Angeles
Kent J. Collings	Fresno Agricultural Works, Fresno
E. P. Condrey	Fresno Equipment Service, Inc., 2514 Vassar Terrace, Fresno
George A. Connell	Pacific Coast Borax Company, 510 West 6th Street, Los Angeles
Ralph W. Cook	Food Machinery Corporation, 1710 Cleveland, San Jose

CALIFORNIA - Continued

Thomas M. Cox	W. T. Cox Company, 1019 Fruit Street, Santa Ana
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Julius C. Deubner	California Farm Bureau Federation, 1185 Glen Avenue, Berkeley
H. H. Dodge	Shell Oil Company, 2030 Forest Street, San Jose
Paul Dougherty	California Polytechnic College, San Luis Obispo
Roger M. Drake	655 Grove Street, San Luis Obispo, San Luis Obispo County Department of Agriculture
Paul M. Dresher	Hurst Industries, 1598 Hanchett Avenue, San Jose
Robert T. Durbrow	Irrigation Districts Assn., 501 Font Elvd., San Francisco
Ryan Eisner	California Lettuce Growers, 145 Palm Street, Santa Maria
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Louis C. Erickson	Thompson Horticultural Chemicals Corporation, 2266 Glendale Ave., Montrose
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David E. Flipsie	Bureau of Reclamation, Box 246, Strathmore
Robert W. Finch	Swift and Company, Fullerton
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B. P. Goethe	Southern Pacific Company, 65 Market Street, San Francisco
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J. R. Hawkins	The Glidden Company, 1300 - 7th St., San Francisco
F. S. Heckathorn	R. J. Prentiss & Co., PO Box 1407, Richmond

CALIFORNIA - Continued

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Esler Johnson	John Powell and Company of California, Inc., 354 North Preda St., San Leandro
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H. R. Offord  
Arthur M. Oppedal  
Mac D. Osborn  
James Osborne  
J. Van Overbeek  
W. B. Parker

Lloyd E. Parks  
F. G. Pellett  
A. G. Perkins  
John C. Phillips  
Harry Piper  
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R. N. Raynor  
Raymond Rebuffo  
Robert T. Reinhardt  
Merwyn D. Riddle  
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J. L. Sanders  
E. Schuler  
George W. Schwiers  
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Frank Walker	Siskiyou County Department of Agriculture, 332 Pine St., Yreka
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Aubra Watson	Brendlin Ranch Company, Rt. 1, Box 137C1, San Luis Obispo
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Percy F. Wright	County Agricultural Commissioner, Santa Rosa
Sheridan H. Wright	Brendlin Ranch Company, General Delivery, Arroyo Grande
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**DOMINION OF CANADA**

Peter Rosgan	Farmer, Munson, Alberta
Swen Swenson	Alberta Seed Growers, 1401 - 4th St., NW, Calgary, Alberta

**COLORADO**

Jess L. Fults	Botany Department, Colorado A & M, Fort Collins
John T. Maletic	U.S. Bureau of Reclamation, 2089 Krameria St., Denver
Willis T. Moran	U.S. Bureau of Reclamation, 2941 Quitman, Denver
Eugene T. Oborn	Bureau of Plant Industry, 1851 South Madison, Denver
John M. Shaw	U.S. Bureau of Reclamation, 905 Ogden St., Denver
Bruce J. Thornten	Colorado Seed Laboratory, Colorado A & M, Fort Collins
George D. Weaver	Production and Marketing Administration, 53 Elizabeth St., Fort Collins

**DELAWARE**

J. V. Miller	Atlas Powder Company, RFD 3, Shipley Road, Wilmington
--------------	---

**HAWAII**

F. C. Denison	Hawaiian Sugar Planters Experiment Station, Honolulu
R. E. Griswold	American Tractors, Honolulu
Dr. Francis E. Hance	Hawaiian Sugar Planters Experiment Station, Honolulu 4

**IDAHO**

A. L. Callow	Fremont County Weed Supervisor, St. Anthony
Raymond Clegg	Bannock County, McCammon
V. A. Cox	Idaho Noxious Weed Association, Box 576, Meridian
Frank H. Crofts	County Weed Control, Idaho Falls
E. E. Davison	E. E. Davison Equipment Company, Box 1993, Boise
Drue W. Dunn	Pocatello
Lambert C. Erickson	U. T., 842 East 7th St., Moscow
George W. Forbes	County Weed Supervisor, 555 South Higbee, Idaho Falls
Arlon E. Frazier	Payette County Weed Control, Payette
H. L. Gault	Director, Twin Falls County Weed Bureau, Twin Falls
Frank E. Goodwin	Box 52, Sweet
Kenyon Green	County Weed Commissioner, Box 892, Twin Falls
H. J. Goemmer	Jerome County, Jerome
Frank E. Hackler	Idaho Experiment Station, Weiser
DeLane M. Hall	Power County Weed Control, Box 45, American Falls
A. C. Hansen	Rexburg
F. W. Hawkins	County Commissioner, Filer
D. K. Handry	Jerome County Weed Control, Jerome
Fred W. Heuer	Jerome County Weed Control, Jerome
Jesse M. Hodgson	United States Department of Agriculture, Meridian
D. L. Huey	Gooding
E. J. Johannesen	County Extension Agent, Emmett
Don Kautz	Washington County, 1030 East Commercial, Weiser
A. V. Kinney	Chaney Wholesale Company, Fruitland
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Gilbert Matsen	Extension Service, Box 534, Payette
Ed Mess	Payette County Commissioner, Payette
Ralph T. Nyblak	Simplot Soilbuilders, Caldwell
James F. McDevitt	Reilly-Atkinson Company, 1020 East Bannock, Boise
C. I. Seely	University of Idaho, 321 South Polk, Moscow
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M. L. Tillery	U.S. Bureau of Reclamation, 3501 Koolenai, Boise
George D. Vanderhoff	Director Idaho Noxious Weed Association, Homedale
Ralph Welch	Gem County, 310 North Johns, Emmett
Bert Weston	Valle Chemical and Fertilizer Company, Wendell
George Whornham	American Chemical Paint Company, 154 - 7th St., Idaho Falls

**ILLINOIS**

Charles S. Morrison	Deere and Company, 2103 - 14th St., Moline
E. H. Rapp	West and Company, Plant Food Division, Chicago

**INDIANA**

G. G. Carpenter	Dobbins Manufacturing Company, 2115 East Jackson, Elkhart
-----------------	---

**KANSAS**

C. W. Bothe	Santa Fe Railway, Topeka
F. L. Timmons	United States Department of Agriculture, Hays Experiment Station, Hays

**MINNESOTA**

Jerome Simer	Jerome Simer Company, 422 Stinson Blvd., Minneapolis 13
--------------	---

**MISSISSIPPI**

H. Fred Arle	State College, Mississippi
--------------	----------------------------



**MISSOURI**

H. F. Shattuck  
 Dr. Lloyd V. Sherwood  
 R. W. Towne

Monsanto Chemical Company, St. Louis  
 Monsanto Chemical Company, 1700 South Second St., St. Louis  
 Monsanto Chemical Company, 1700 South Second St., St. Louis

**MONTANA**

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 B. L. Clemm  
 Harry C. Johnson  
 K. P. Jones  
 G. F. Kritzberg  
 Owen P. Lavin  
 H. Elwood Morris  
 E. W. Nelson  
 H. Clay Scott  
 L. A. Wollam

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 Montana Flour Mills, Great Falls  
 Montana Flour Mills, Great Falls  
 Harlowton  
 Johnson Flying Service, Missoula  
 Van Waters and Rogers, Inc., 1408 - 1st St. West, Billings  
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 Johnson Flying Service, Missoula  
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Del Digney

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**OHIO**

Dr. C. J. Willard

North Central Weed Control Conference, Ohio State University,  
 Columbus

**OREGON**

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 A. G. Bergreen  
 Herman E. Burman  
 Clarence E. Brissenden  
 C. L. Cummings  
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 Harley H. Franklin  
 Virgil H. Freed  
 C. L. Hackensmith  
 H. L. Hagen  
 L. E. Harris  
 M. G. Huber  
 C. B. Jackson  
 Vic Johnson  
 A. J. King  
 Ivan R. Myers  
 Raymond A. Miksche  
 Roy E. Miller  
 Frank McKennon  
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 Olin V. Poe  
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 Oregon Experiment Station, 1717 Main Street, Klamath Falls  
 DuPont Company, 2807 Orchard St., Corvallis  
 Peoples Warehouse, 4144 Summers Ave., Klamath Falls  
 Agronomy Division, Oregon State College  
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 Chipman Chemical Company, 3100 SE Ankinney, Portland  
 Oregon State College, 103 North 27th St., Corvallis  
 Standard Agricultural Chemicals, 9442 North Chicago, Portland  
 Umatilla County Agent, Pendleton  
 W. R. Grace Company, 738 Mead Bldg., Portland 4  
 Medford  
 Medford  
 Miller Products Company, Portland  
 Oregon Department of Agriculture, Salem  
 Dow Chemical Company, 2745 Arnold Way, Corvallis  
 Phoenix Grange, Rt. 4, Box 260B, Medford  
 Oregon State College, 914 Monroe, Corvallis  
 Mid-Columbia Supply & Equipment Co., Rt. 3, The Dalles  
 Oregon Agricultural Chemicals, Peineville  
 Klamath County Weed Control, Rt. 3, Box 445, Klamath Falls

**OREGON - Continued**

Kirt Skinner  
 Charles H. Starker  
 Fred H. Schiller  
 M. E. Sylvester  
 J. D. Vertrees  
 Clyde Walker  
 Rex Warren  
 C. V. Zehrung

VanWaters and Rogers, Inc., Portland  
 Chemical Division, Pacific Supply Co-op, Rt. 6, Box 1180, Portland  
 Weed Control Service, Inc., Tigard  
 W. R. Grace Company, 738 Mead Bldg., Portland  
 Stauffer Chemical Company, PO Box 68, North Portland  
 R. M. Wade & Company, 106 S.E. Hawthorne, Portland  
 Oregon State College, Corvallis  
 Zehrung Chemical Company, 2201 Northwest 20th St., Portland 9

**PENNSYLVANIA**

R. F. Byrnes  
 Leon Cherkasy  
 Charles William King  
 W. W. Tranter

Rohm and Haas Company, 222 Washington St., Philadelphia  
 American Chemical Paint Company, Ambler  
 Messinger Manufacturing Company, Tatamy  
 A. B. Farquhar Company, 1534 - 4th Ave., York

**TEXAS**

R. S. Bristol  
 C. L. Heimbach  
 W. H. Mercer

U. S. Bureau of Reclamation, PO Building, Amarillo  
 Atchison, Topeka and Santa Fe Railway, Pantex  
 U. S. Bureau of Reclamation, PO Building, Amarillo

**UTAH**

Glenn T. Baird  
 T. L. Blanchard  
 Wynn L. Davis  
 H. W. Gore  
 W. Harold Hirst  
 George L. Hobson

Utah State Agricultural College, Logan  
 State Department of Agriculture, 250 East 2nd South, Smithfield  
 State Department of Agriculture, Courthouse, Brigham  
 State Department of Agriculture, Richfield  
 Bureau of Reclamation, Salt Lake City  
 State Department of Agriculture, Weed Eradication, 412 State  
 Capitol, Salt Lake City

Myron Madsen  
 V. L. Martineau

U. S. Department of Agriculture, Monroe  
 Salt Lake County Agricultural Agent, 1465 Sherman,  
 Salt Lake City

Morgan Regan  
 Emil Savage  
 Elmer Smith  
 Edgar L. Sorenson  
 A. Stark  
 LaVar W. Thatcher  
 D. C. Tingey  
 Roy Whiting

Steve Regan Company, 1122 East 7th St., Salt Lake City  
 Porter Walton Company, 1170 Richard St., Salt Lake City  
 Denver Fire Clay Company, Salt Lake City  
 State Department of Agriculture, Salt Lake City  
 Wasatch Chemical Company, Salt Lake City  
 Wasatch Chemical Company, 2225 South 5th St., Salt Lake City  
 Utah Agricultural Experiment Station, Logan  
 State Department of Agriculture, 722 C & C Bldg., Ogden.

**WASHINGTON**

M. J. Benjamin  
 P. J. Blanchett  
 A. E. Bonn  
 V. F. Bruns  
 M. W. Choate  
 E. B. Clark  
 Ralston R. Cunningham  
 Robert D. Eichmann  
 C. E. Graves  
 Cecil Hagen  
 Lee Hansen  
 F. A. Holmes  
 Errol H. Karr  
  
 A. W. Lange

Van Waters and Rogers, Inc., 809 Washington St., Spokane  
 Dow Chemical Company, Rt. 8, Yakima  
 VanWaters and Rogers, Inc., 4000 - 1st Avenue S, Seattle  
 U.S. Department of Agriculture, 1112 Playfield Ave., Prosser  
 Sherwin-Williams Company, PO Box 1462, Yakima  
 Chemi-Serve, Inc., 7315 East Marginal Way, Seattle  
 73 Columbia St., Seattle  
 Stauffer Chemical Company, Box 225, Pullman  
 DuPont, 4115 North 38th St., Tacoma  
 Pacific Northwest Farms Trio, 17 West 25th Ave., Spokane  
 Pacific Coast Borax Company, 521 - 36th St, North, Seattle  
 DuPont Company, Box 595, Wenatchee  
 Pennsylvania Salt Manufacturing Company, 624 North M Street,  
 Tacoma  
 Spokane County Weed Control, Fairfield

WASHINGTON - Continued

J. B. McCambridge	Chipman Chemical Company, 148 South 9th St., Hillsboro
A. Hayes McCoy	Pennsylvania Salt Manufacturing Company, 306 Park Ave., Yakima
W. C. McMinimee	State Department of Agriculture, 922 - South 16th St., Yakima
L. A. Rasmussen	Washington State College, 1601 Fisk Street, Pullman
W. M. Senske	Chemical Products Company, 919 West 12th St., Spokane 9
W. A. Shearing	Sherwin-Williams, Rt. 2, Selah
L. P. Smith	VanWaters and Rogers, 2611 South Tehos, Spokane
C. J. Tjernagel, Jr.	NACO Manufacturing Company (W. R. Grace Company) Mt. Vernon
C. F. Trombley	Monsanto Chemical Company, 911 Western Ave., Seattle
Ed L. Turner	Pictsweet Foods, Inc., Rt. 4, Mt. Vernon
Phil Watke	American Chemical Paint Co., 601 Grand, Pullman
Hugo H. Wiese	Klemgard Pea Processing Company, Pullman
George Wilcox	Douglas Weed Eradication District, Waterville

WASHINGTON, D. C.

Robert B. Balcom	U. S. Bureau of Reclamation, Washington
Lewis Evans	United States Department of Agriculture, Beltsville, Maryland
K. S. Quisenberry	United States Department of Agriculture, Beltsville, Maryland

WYOMING

Charles E. Allen	State Seed Laboratory, Laramie
Dale W. Bohmont	University of Wyoming, Laramie
F. A. Chisholm	Extension Service, University of Wyoming, Laramie
George B. Harston	Office of State Entomologist, State Department of Agriculture, Powell

The reading of the minutes of the previous meeting was dispensed with. President Freed then requested the Secretary-Treasurer to give the Treasurer's report.

REPORT OF THE TREASURER  
January 1, 1948

1946 Balance .....		\$ 358.94
1947 dues collected .....		545.00
Exhibit fees, Portland .....		30.00
Banquet tickets, Portland .....		304.00
Registration fees, Portland meetings.....		360.00
Expenses in connection with Portland meeting (banquet, rental of sound equipment, stenographic service, etc)....	\$ 579.90	
Western News Service, minutes of Portland meeting .....	400.00	
Expenses of Walter S. Ball to Topeka, Kansas to attend meeting of North Central Weed Control Conference .....	192.00	
	\$1,171.90	\$1,597.94
	426.04	
	\$1,597.94	\$1,597.94

The morning session adjourned at 11:45

## MONDAY, FEBRUARY 2

### Afternoon Session

The meeting reconvened at 1:15. President Freed opened the meeting with the introduction of C. E. Hutchison, Dean of the College of Agriculture, University of California, who gave the opening address of the formal program.

The other speakers on the afternoon program included W. W. Robbins, A. A. Brock, Lewis Evans, Robert Balcom, W. T. Moran, and James Holloway who were introduced by Chairman Freed preceding their appearance on the program. Following are the papers which were presented:

## WEED CONTROL DEVELOPMENTS IN CALIFORNIA

Dr. C. B. Hutchison  
Dean, College of Agriculture  
University of California

It is not necessary for me to tell you how happy I am to open this Tenth Annual Western Weed Control Conference, for anyone who is concerned with the welfare of agriculture is of necessity interested in your important work. The rapidly growing concern in the weed problems of the Western States is exemplified well by the large attendance I see here today. Assembled here, I am told, are official representatives of the State and County agricultural organizations, research workers, agricultural extension specialists and representatives of commercial organizations engaged in the manufacture of herbicides and of equipment for their applications. To those who come from other states we give an especially warm welcome.

I note from the program that tomorrow this group of workers is to hold its meeting on the Davis campus. We welcome you to this branch of the University of California, where most of our work with weeds is being done. Our facilities are at your disposal. We are somewhat crowded there this year, due to the heavy post-war enrollment; you will observe that we have erected some temporary buildings to relieve the pressure and that some permanent ones are under construction. Under way now are two buildings for soils and irrigation, and one for the plant sciences. A school of Veterinary Medicine is next in order and there are also to be a poultry building, one for home economics, another for food technology, and a student health center. Some ten millions of dollars are involved in this program, exclusive of dormitories which we hope also to have to provide suitable living quarters for our ever growing student population.

Weed research by the California Agricultural Experiment Station was definitely organized as a project in 1930, in the Division of Botany, and under the direction of Dr. W. W. Robbins, who I see is to follow me on this program. From the beginning, the personnel of the Botany Division of the Experiment Station and that of the California State Department of Agriculture charged with the enforcement of that part of the State laws relating to weed control, have worked closely together. This relationship has been most happy and fruitful. I attribute the rapid strides in the solving of California weed problems in which both agencies may take much pride, to this close cooperation between the State Department of Agriculture and the College of Agriculture. Indeed this weed control program is a typical example of the splendid cooperative relationships that have existed for many years between these two public agencies to the material benefit of California agriculture.

Three major projects initiated and carried through

by the State Department of Agriculture in its contributions to the solution of practical weed problems in California are particularly outstanding. These are: the eradication of artichoke thistle from some 70,000 acres of range lands in Solano, Contra Costa and Napa Counties; the almost complete eradication of camelthorn which had spread to thirteen California counties, infesting perhaps a thousand acres at its peak; and the successful prevention of the spread of a heavy infestation of the perennial Austrian field cress in Modoc County. Many other instances could be mentioned of significant services that have been rendered by the State Department of Agriculture and the County Agricultural Commissioners in lessening the losses due to weeds and in the prevention of the introduction and dissemination of weeds new to our State.

It is well recognized that effective weed control in any area demands organized cooperative efforts: cooperation of Federal, State, and County officials, of property owners, irrigation districts, power companies, railroads, seed companies and warehousemen. It calls for research for new and improved methods of control, the broadcasting of information, its application to the problem at hand, and the support and enforcement of regulatory measures.

Weed control is of consequence in every community, and to practically every property owner in the community. This applies to owners of farms, orchards, vineyards, range lands, and to those who live in cities and towns. Weed control also is of concern to the State and County highway organizations, power and telephone companies, city park and street commissions, and golf clubs. Every individual and every group concerned with vegetative growth, experiences at one time or another the problem of practical control of weeds. Attention also must be given to the development and improvement of machinery and equipment for cleaning crop seeds and to apparatus used in the application of herbicides and in cultural control of weeds.

It is not easy to estimate the agricultural losses caused by weeds. The committee reporting on the Efficacy and Economic Effects of Plant Quarantine in California, as published in California Agricultural Experiment Station Bulletin 553, applicable to the period 1929-1931, states that the growers of California expended at that time an annual sum of \$18,620,000 for weed control. This, however, does not represent the total losses, direct and indirect, caused by weeds.

In farm management studies it has been found that the cultivation of crops cost about 16 percent of the total value of the harvest; and that approximately one half of the cultivation is made necessary by the presence of weeds. In California, in 1939, there were 4,545,000 acres of field and garden crops valued at \$218,000,000. The cost of cultivation made necessary

by weeds, figuring on 8 percent of the value of the crop was \$17,440,000. Orchards and vineyards in 1939 produced crops valued at \$154,793,000. We have no studies which will enable us to estimate costs of cultivation for weed control among trees and vines, but it is safe to say that the total annual weed tax due to cultivation in California is several million dollars. We have a total here of not less than 30 million dollars. These are 1939 figures; The weed tax today is considerably more.

It should be mentioned at this point that some fifty thousand acres of citrus groves in California now operate under a non-cultivation program; weed growth is held in check by oil sprays. More recently, olive growers have become interested in this method of orchard management.

There are, too, other losses brought about by weed infestations. Among these are reduced crop yields, increased cost of preparing crop products for consumption, and the losses due to insects and fungi which are harbored by weeds growing among crop plants, along fence lines, in corners hard to cultivate, and on roadsides and ditchbanks. The first cutting of many old stands of alfalfa may be so fouled with weeds that there is a serious reduction in feeding value. I doubt if we ever have realized fully how serious weeds are as a natural breeding ground for insects and fungus pests which attack crop plants. Here are some examples: leaf hoppers which carry curly top virus of sugar beets, garden beets and western yellow blight of tomatoes, living on Russian thistle and other weeds; the fungus causing downy mildew of lettuce, harbored by prickly lettuce, sow thistle and other members of the composit family; bean thrips which flourish on species of wild lettuce; insects living on a variety of weeds which carry the virus causing Pierce's disease of grapevines; the weevil which infests peppers, living over winter on a species of nightshade. Many other examples could be cited, each of which causes a definite and serious monetary loss to the farmer.

The weeds of range lands in the Western States have seriously reduced the grazing capacity of these areas. Some 25 millions of acres of California range lands are dominated by introduced annuals, most of which are inferior in feeding value to the native grasses which once flourished there. We need only to cite the hypericum known as Klamath Weed or St. Johnswort which now infests well more than a hundred thousand acres of grazing land in Humboldt County alone, and now has spread to 26 counties. The California Agricultural Experiment Station has been studying the control of Klamath Weed in three ways. First, with chemicals; second, with range management practices; and third in cooperation with the United States Department of Agriculture, by means of biological control with three species of beetles introduced from Australia and France.

I have touched upon only a part of the losses which

weeds cause. We must come to recognize weeds as being on a par with insects and fungus diseases as enemies of agricultural production. Success or failure of a crop is often related to the absence or presence of weeds. There is a close correlation between proper and timely farm practice and operation, and the degree of weed infestation. When we have taught a grower effective weed control, we have at the same time taught him the necessity of crop seeds free of weed seeds, the value of crop rotation, the proper methods of soil management, the right use of farm implements, and the proper manner of handling manures and feed stuffs.

A number of years ago, the staff of the Division of Botany of the College of Agriculture, in cooperation with Mr. Walter S. Ball, Chief of the Bureau of Rodent and Weed Control and Seed Inspection of the California Department of Agriculture, prepared a manuscript for a Circular on weed control which the College published. It was one of those comprehensive publications which covered many phases of weed control. It became known as the Robbins-Ball weed control bible. Although forty thousand copies of this circular were printed and distributed, we have come to realize that such all-inclusive publications are not of maximum usefulness to the farmers of the State. This has become particularly evident in view of the striking developments in practical weed control in the last seven years. Accordingly, we now are issuing a series of attractive and readable short circulars each covering a specific phase of weed control. These have been exceptionally well received.

As I look over these circulars and similar ones from other Agricultural Colleges in the country, I am impressed with the great difference between them and the weed publications of some 15 or 20 years ago. Formerly, emphasis was laid on weed identification; there were botanical descriptions, often poor line drawings and half tones, which were of little help to the reader in aiding him to know the weeds on his farm, much less to help him in an eradication program. There was a noticeable, a pathetic lack of definite information on control. I take it this was due to the fact that no definite body of scientific knowledge had been developed on which to base control measures. In contrast, current weed publications emphasize control because research, in the meantime, has produced that knowledge; the authors now have something definite to put into print. We, at the University of California College of Agriculture, are determined to make these publications for farmers of value to those for whom they are intended by basing our recommendations for control upon scientific facts.

The shortage of labor and its high cost, the increasing prices of most farm crops, and a rather rapid spread of noxious weeds which occurred during the war period, created an urgent demand for improvements in practical weed control methods. Concentrated research, coupled with field demonstrations and co-

operation with all agencies concerned, brought into use from 1940 to the present time more revolutionary changes and improvements in chemical methods of weed control than had taken place in all agricultural history prior to that period. May I enumerate a few of the most important of these developments?

1. Wide application of selective herbicides to control weeds in fields of small cereals, including rice, corn, milo, and flax, and in peas, alfalfa, onions, carrots and celery.

2. The discovery of growth-regulating substances as weed killers, chiefly 2,4-D and its substitutes.

3. The use of dinitro compounds as general contact herbicides, especially as fortifiers of oil.

4. Development of more effective soil sterilization methods available for ditchbanks, roadsides, fence lines, playgrounds, walks, and driveways and about buildings, signboards, and telephone and telegraph poles.

5. Marked progress in the knowledge of carbon disulphide as a soil sterilant, particularly the various field factors which influence its effectiveness.

6. General improvement in weed control machinery and equipment, including nozzle tops, pressures, and volumes. Here we must not overlook the use of the airplane in applying herbicides.

The farmers of California have expressed a desire for an expanded weed research program. More facts are needed on which to base control measures. Research on weeds cuts across every commodity group, and findings concerning the control or eradication of any particular weed apply to many agricultural situations. For example, the wild morning glory is a serious pest in almost every California crop. It seems obvious that the time has come when nearly every primary noxious weed requires the same concentrated study that an entomologist would give to the investigation of a specific insect pest, or that a plant pathologist would give to a specific fungus. The development of effective and practical weed control methods requires men trained in plant physiology, plant morphology, soils, chemistry, and agricultural engineering. Demanded is fundamental research, just as fundamental as is required of investigators in any other field of agriculture. The phenomenal progress in weed control in the last few years has been possible only because of the research that has been directed at this problem. There can be no doubt that further progress will come only from additional knowledge and that knowledge can come only from additional research.

In this basic weed research the College of Agriculture expects to continue, for through it, we are convinced, we shall be able to make further important contributions to the welfare of agriculture and of the State. I am sure all of you share with me pride in the work that has been done in this field by Professor Robbins and his associates at Davis. They

have blazed new trails which now many travel. We have only to recall the saving of the government contracted carrot and onion crops by means of selective sprays during the war and the latest contribution, pre-emergence sprays for row crops, as examples in a long list of accomplishments to be assured of the importance of their work and to be convinced that it must proceed.

The College of Agriculture, I assure you, is unreservedly for your weed control program.

## REGULATORY ASPECTS OF WEED CONTROL

A. A. Brock

Director

California Department of Agriculture

Perhaps the invention and use of the atomic bomb has called more forcefully to the attention of the world the true value of research than any other thing that has ever happened.

While we have had many examples in the past of inventions and discoveries made through research, this perhaps has been more spectacular than any other thing previously recorded. We have only to look back a few years to remember the introduction of the steamboat, cotton gin, telephone, electric light, automobile, radio, wireless, airplane, and many other things which might be enumerated, and all have meant a great deal to mankind. They have lessened his burdens and given him more time to enjoy life.

While we are more concerned with agriculture than industry, we know that much of the drudgery of agriculture has been removed as a result of research and invention. We know that new varieties have been discovered which have increased size, flavor, and looks of many commodities; the yield in others has been greatly increased. Some varieties have been found which are resistant to disease, also.

In livestock we have improvements in breeds which have been made through research; and in the control of animal diseases, vaccines have been developed. In the field of plant life, in addition to the varieties discovered, new insecticides, fungicides and herbicides have been developed through research that have meant a great deal to agriculture. Recently, two have been put into use -- DDT for insects and 2,4-D for weeds.

After research has developed some new products or new methods, it is necessary to educate the general public or those in a particular industry to the proper use of those commodities. This requires time, effort, and money; and in the field of research and education a great deal of money has been expended. No doubt, in the main, the returns have been ten-fold or better. Without the advancements that have been made in agriculture, it would perhaps be difficult to produce the quantities of food that we are producing today. Perhaps it could be done by using a greater percentage of our manpower, but as a result of these inventions,



large numbers of men have been released for industry. Thus, through mechanization of agriculture and improvements which have been made through research and invention, we are permitted to enjoy many luxuries that could not otherwise be manufactured because a great percentage of our total manpower would be required to produce our food and clothing.

In discussing these several functions, I am trying only to point out the value and importance of research and education. While perhaps I have done a very feeble job, I am only leading up to another field which is perhaps not as spectacular but is as important. In our work the main job is to carry out regulations. These regulations might be considered the rules of the game in the industry with which we are concerned. For instance, in the Department of Agriculture we have some seventeen bureaus; practically everyone has to carry out some or many regulations; some render a given type of service; others carry out very definite procedures which allow a service but indirectly, in the main, are designed to regulate an industry. Those who engage in the handling of farm commodities must be bonded and live up to certain regulations. Those who grow nursery stock must produce clean stock and comply with regulations in the movement from one area to another. In the field in which you are particularly concerned, seed men must live up to the regulations provided to prevent the spread of noxious weeds, and also to inform purchasers of the purity and the germination quality of the farm seeds in which they deal. Similar regulations are provided for the handling of livestock to prevent the spread of animal diseases. Many of our crops are carefully graded and a definite standard is set up for them; products offered for sale below this standard are in plain violation of the law. The quality of our butter and eggs is watched and those who fail to comply with the requirements are penalized. Our milk is carefully inspected to see that it meets a certain grade when used for human consumption. Meat is inspected when slaughtered.

Many people feel that agricultural regulations are of little or no importance because they are not normally as spectacular as murder trials or prosecutions for theft or robbery, but, in the main, they are more important to the general public for the reasons that they are designed to prevent deception, cheating, and possible injury. In many cases where agricultural regulations are not enforced, sickness, injury or death may result.

As a rule when an individual has been found violating a law, he is either doing it through lack of knowledge of the regulation or deliberately. If deliberately, he most likely will do most anything or everything in his power to avoid the penalty, and immediately he tries to make the enforcement officer look silly; many times he is successful in convincing the public as well as the court that the officer is the culprit rather than himself. In other words, enforcing

any type of law is anything but a pleasant job and one in which not too many people are interested. To properly perform their duties in enforcing agricultural regulations, a technical knowledge and quite a few years of training are required of the enforcement officers--and too often the pay is not very enticing; nevertheless, someone has to do the job. I think we know without reasonable regulations which the general public accepts, we would be in a state of chaos, because no one would know what to do regardless of whether he was honest or otherwise; there are some who would want to take advantage of the situation and would be operating without any rules, or perhaps governing, in which case there would be a seige of anarchy.

I think we can further demonstrate the value of reasonable regulations because every time a new discovery is made it carries with it a need for regulations. We have only to look at our present regulations which are designed to prevent deception and to provide protection to those who use some of these products. We could point out that insecticides and fungicides must be applied correctly, at the right time, and with the correct dosage, or the person who is purchasing them and is presumably the benefactor may be injured very seriously. In addition to this, application of these products may injure innocent adjacent property owners. We need only to consider some of the new discoveries which make these regulations important. Let us consider the application of 2,4-D for the control of weeds; first, the owner who applies it for his own benefit, or a commercial operator who applies it, must know exactly when and how to apply it, and then the adjacent property owner must be protected. This is true also in the use of insecticides and fungicides. DDT is a product which requires time and patience in order to make sure that injury does not result from its application.

The importance of weed control is certainly well understood by all of you gentlemen. Too often, I think, too little attention has been given to the overall matter of control or eradication of weed pests. A good many years ago it was estimated that insect pests alone in this country cost American farmers over a billion dollars annually. I presume this took in losses plus costs of control. It has also been estimated that plant diseases took a toll of a similar amount. It has been stated that weeds have been responsible for losses equal to the combined tolls taken by insect pests and plant diseases. I think we can readily understand this because our methods of control in the past have been laborious and expensive and not too efficient.

Where field crops are grown year after year, and some perennial becomes established, it is a fight to determine whether weeds or man will win the battle.

In row crops where the center of the row can be mechanically handled, it is the good-old-fashioned hoe

that must be used to prevent the weeds from choking out small plants and taking the moisture and plant foods which will reduce yield or result in crop failure. Millions of acres of rangeland have been taken over by weed pests and the value has been reduced to almost nil for grazing purposes. So, when we consider what we see every year in connection with what weeds can do, there certainly can be no question of the losses resulting from infestations throughout the nation. I am persuaded that the estimates made a good many years ago would be doubled perhaps at this time if we could accurately account for all losses resulting from weeds. This, of course, would vary with the price of the commodity grown. At this time livestock which are grown on lands that furnish little or no feed would produce quite heavy losses to the owners of such land.

If it were possible to persuade everyone through education to avail themselves of the advantages resulting from research, the battle could perhaps stop there, but it is a well-known fact that it is impossible to get everyone to fall in line with any procedure or new development and therefore if we are all to profit from such discoveries, we must make the man who is inclined to refuse, or neglect, to apply methods which would not only be beneficial to himself but a protection for his neighbor comply with the procedure. In order to do this, we must enforce regulations, and that is one of the duties of our Department as well as the Agricultural Commissioners--to stamp out if possible newly discovered infestations of noxious weeds and to see that those that are pretty generally distributed are controlled when they become a public nuisance. Therefore, the true value of carrying out regulations is just as important as the other phases we have discussed for the reason that if only a half job is done, eventually those who are expending every effort may become discouraged and give up or they may sell their land because they are unable to cope with the situation without the cooperation of their neighbors.

Of course, a great impetus has been given to weed control work in the discovery of 2,4-D and other herbicides, 2,4-D occupies in your field pretty much the same position as the atomic bomb in warfare.

The discovery and use of the atomic bomb brought with it perhaps more problems than it solved, but its discovery was spectacular and came at a time when needed. It is now a very serious problem for the United Nations. While you would think it would be a very definite reason for attempting to stop all wars, even more wrangling over its control has resulted than over many of the other problems facing this important body. I am persuaded that if some simple rule could be found and an adequate police force could be set up upon which all the nations could depend to prevent wars, I think it would be a greater boon to mankind than all the discoveries or inventions which have been made to date.

## HISTORY AND DEVELOPMENT OF WEED CONTROL

W. W. Robbins

Botany Division, College of Agriculture  
University of California at Davis

The history and development of weed control and of agriculture are parallel. Undesirable plants have always interfered with the growth of crop plants. When acreages were small and labor plentiful and cheap, and the farmer and his family worked their own fields, the hoe and other simple cultivating implements sufficed; weeds were taken for granted; there was no urgent need for special tools and methods with which to combat weeds. In time Agriculture became an industry; problems of costs and profits arose; weeds arrived from somewhere and multiplied rapidly; costs increased because of weeds man began his struggle against these enemies of production. The struggle has become more serious and strenuous as the years have passed by. We can safely say that today one of the principle problems of all growers of plants is the control of weeds.

Only briefly will we review the trend that weed studies and weed control methods has taken, particularly in this country.

**REPRODUCTION OF WEEDS**--There are numerous studies on the seeding habits of weeds, their means of seed dissemination, the longevity of buried seeds, the dates of germination and maturing of seeds in relation to planting and harvesting dates of crops, and the spread of weeds vegetatively. Investigations convince us of the importance of wind, water, and animals, including man, as agencies of weed seed dissemination.

As to germination of weed seeds, we have the excellent studies on dormancy by Atwood, Crocker, Shull, Davis and Gill. Dr. Beal's seed-viability experiment on the longevity of buried seed, started in 1879, will long remain famous. There is a considerable literature having to do with the effect of submergence in water on the viability of weed seeds; also the effect of fire, herbicides, composting, ensiling, and digestive action of animals on the viability of such seeds. There is, however, a dearth of studies on vegetative reproduction of weeds, although the work of Kiltz, Pavlychenko, et al, Frazier, and Arny are worthy of mention.

**ASSOCIATION OF WEEDS WITH SOILS AND CROPS**-- Limited studies have been made of weed distribution and crop character in relation to soil type, and of the relation between soil reaction and nature of weed growth. A few studies deal with the characteristic weeds of different crops. Notable are the contributions of Brenchley and Warrington based upon findings on the plots and Rothamsted and Woburn.

**COMPETITION BETWEEN CROP PLANTS AND WEEDS** -- We need refer here to the excellent investigations of Pavlychenko et al on the competing ability of different plants, and its relation to control methods. Also, I

would direct your attention to Varma's studies on the nature of competition between plants in the early phases of their development; to those of Godel on the effect of weed competition upon crops; to those of Blackman and Templeman on the nature of the competition between cereal crops and annual weeds; to the classical studies of Cates and Cox (1912), of Call and Sewall, and of Kieselbach et al., who demonstrated that in corn the beneficial effect of tillage was the removal of weeds; to the investigations of Rademacher in Germany, of Godel in Canada, and others, on the date and rate of seeding, and the application of fertilizers as they affect the growth of weeds in a crop; and to the studies of Arny et al. on the value of competitive crops in weed control.

**ORGANIC RESERVES OF THE UNDERGROUND PARTS OF PERENNIAL WEEDS.** -- Special mention should be made of the researches of Arny, of Barr, of Welton, of Timmons, et al., which emphasized the value of organic reserve studies and the great need for such studies if effective control methods are to follow.

The foregoing briefly refers chiefly to purely botanical studies concerned with weeds. Often these investigations had no practical objective, although in toto the results have aided materially in the development of control practices. We should not minimize their importance; rather, they emphasize the need for botanical investigations of fundamental weed problems more directly aimed at control methods.

In the United States all the early weed bulletins or circulars or manuals laid emphasis on species identification. There was usually a full-page description including a more-or-less helpful line-drawing, and only two or three lines dedicated to control. Suggestions for control usually referred to nothing more than use of the hoe and frequent cultivation. It should be added that these early weed publications were written by botanists--pure botanists--who probably degraded themselves greatly by stooping so low as to be concerned with weeds. And, undoubtedly their feeble attempts to give control methods were only a reflection of their profound ignorance. Moreover, botanists have not given sufficient attention to life history and physiology of weed species; they have not used them as illustrative material in their teaching; for the most part, weeds have been studiously avoided. The literature pertaining to the morphology of a rare tropical cycad will fill pages; of Johnson grass, perhaps two lines.

Weed control receives very little attention even in our agricultural college teaching. There may be a lecture or two in an agronomy course. There have been very few attempts to organize substantial, comprehensive courses. On the other hand, courses in plant pathology and entomology are well formulated, and even include graduate study. In large part, I blame botanists for this situation.

**SPECIAL WEEDS.** -- Any one of us here could make a list of specific weeds which are major agricultural

pests, are causing annual losses amounting to millions of dollars, and which demand very special study. Undoubtedly the best example of a well-organized, and well-executed attack on a specific weed is the bindweed project of the United States Department of Agriculture. The relatively few thousands of dollars expended by our government on this project have already saved the farmers of central-western states millions of dollars. This project should serve as a pattern for similar studies directed at other noxious weed species. We need to tackle the problem of control of a specific weed by the same methods as a plant pathologist investigates a certain disease, or an entomologist studies a certain insect pest. The investigation may involve methods of reproduction, seed germination, seed distribution, life history, food reserves, morphological and physiological studies, and the evaluation of the various known methods of control--cultivation, cropping, biological, chemical, or a combination of these.

**SPECIAL WEED PROBLEMS.**--In addition to the need for detailed studies of certain weed species, there are the weed problems of special crops or situations. Here we may mention weeds of grasslands, both natural grasslands and irrigated pastures, weeds of turf, weeds of alfalfa, or small-grain fields, row crops, orchards, and vineyards, of roadsides, of ditches, drainage canals, lakes and streams. The Bureau of Reclamation is taking the lead in the Western States in the study of the weed problems of waterways.

**TILLAGE METHODS OF WEED CONTROL.**--Tillage alone, or in combination with cropping, is the oldest method of weed control; it is still a standard and reliable procedure, and undoubtedly always will be. In the development of tillage machinery, objectives other than weed control have often been paramount. Special weeding tools have been devised, such as the rotary hoe, the rod weeder, the straight blade, the duckfoot, the "finger" weeder, the spike-tooth harrow, and the loose-chain harrow. In our opinion, agricultural engineers need give more attention to the development of tillage machinery adapted for specific weeds and specific groups.

**BIOLOGICAL CONTROL OF WEEDS.**--The first attempt at biological control of a pest plant was carried out in the Hawaiian Islands by Perkins and Swezy in 1924. The pest was a thorny shrub, *Lantana camara*. Insects were found which were effective in controlling *Lantana*, but unfortunately other species of trees and shrubs came in when *Lantana* disappeared, and some of these were more difficult to control than *Lantana*.

The outstanding example of biological control of plants is that of prickly pear in Australia. The story is familiar to all of you.

There are other examples of more or less successful biological control of weedy plants, e.g. *Senecio jacobea* in New Zealand, *Acaena sanguisorbae* in New Zealand and Australia; *Ulex europaeus* in New Zealand, Australia and Tasmania, and more recently *Hypericum perforatum* in Western United States.

**DISCOVERY OF SELECTIVE HERBICIDAL ACTION.**--Little progress was made in the scientific investigation or the practical use of weed killers until the latter part of the 19th century. Then with amazing rapidity, the newly developing science of chemistry found many applications in industry and agriculture. The development of the chemical theory of plant nutrition by Liebig and the increasing use of chemical fertilizers pointed the way to entirely new practices in agriculture. The introduction of Bordeaux spray for plant-disease control heightened the interest in the use of chemicals. Apparently the discovery of the selective action of copper salts on broad-leaved weeds in cereal crops resulted accidentally from trials on the control of fungus diseases. Almost simultaneously, and quite independently, Bonnet (cited by Rademacher, 1940) in France, Schultz (1909) in Germany, and Bolley (1908) in America, found that solutions of copper salts applied to mixed stands of broad-leaved weeds in cereals would kill the former and harm the latter little, if any; this occurred in 1896 and 1897. In the latter year, Martin, in France, used iron sulphate for the same purpose, and Duclos (1897) had success with both sulphuric acid and copper nitrate. By 1900, it was shown that solutions of sodium nitrate, ammonium sulphate, and potassium salts were also successful as selective herbicides, and the practice of spraying for the control of mustards and other common grain field weeds soon spread throughout Europe and the British Isles. Somewhat later, dry powdered kainite and calcium cyanamide were added to the list of selective herbicides. On small farms where hoeing and hand-pulling had been commonly used, spraying and dusting methods saved much time and labor. On these small, intensively cultivated farms, careful application, generally high humidities, and the pressing need for high yields all tended toward the successful use of the method.

Meanwhile, Bolley (1908), in North Dakota, reporting 12 years of successful experimentation with common salt, iron sulphate, copper sulphate, and sodium arsenite stated.

".....when the farming public has accepted this method of attacking weeds as a regular farm operation... the gain to the country at large will be much greater in monetary consideration than that which has been afforded by any other single piece of investigation applied to field work in agriculture, not even excepting the now generally used formaldehyde method of seed disinfection which has saved the State of North Dakota, annually, wheat and other cereals to the value of several millions of dollars."

The American Steel and Wire Company of Chicago became interested in the use of iron sulphate as a weed spray because it offered a profitable outlet for a by-product of their industry. As a result of their activities, demonstrations on the control of weeds in grain fields were carried on in several

states in 1906, 1907, and 1908.

Clive (1909) of South Dakota, Moore and Stone (1909) of Wisconsin, Adams (1909) of Rhode Island, Pammel and King (1909) of Iowa, and Selby (1910), of Ohio, all reported success with iron sulphate. They agreed that spraying should be done during clear weather, when there is little danger of rain, but that the humidity should be high enough to prevent excessive evaporation. Rapid drying of the solution on the plant resulted in crystallization of the chemical on the leaves, which reduced the effectiveness of the treatment.

Following this initial period (1896-1910) of development, interest in the control of annual weeds lapsed in America. The lag in the production of adequate spray machinery, the frequent lack of success because of low humidity, and, above all, the immense scale upon which grain farms were operated, precluding the possibility of completing within the short time during which both weeds and cereals were in the proper stages for treatment, a successful spray program, all contributed to this declining interest. With the introduction of cleaner seeds, the change to a fallow system, and the adoption of new crops, the weed problem was somewhat alleviated, and interest in chemical weed control gradually shifted to other types of weeds, particularly to the perennials.

**DEVELOPMENT OF SELECTIVE WEED CONTROL IN EUROPE.**--But, although interest lagged in America, a new period of development had started in Europe (Aslander, 1927). Rabate (1911), reporting experiments with copper sulphate, iron sulphate, and sulphuric acid on winter wheat concluded that the acid in 6 to 10 per cent solutions (that strength depending on local conditions) was a thoroughly satisfactory spray for grainfield weeds. It killed most of the annual weeds, left the cereals practically uninjured, and had a fertilizing effect upon the soil. Morettini (1915), in Italy, Rabate (1926), in France, and Korsmo (1932), in Norway, found that the selective sprays not only killed most of the broad-leaved weeds in cereals but in many cases resulted in a definite increase in yield. An average of 211 of Korsmo's (1932) experiments carried out from 1914 to 1922 in spring-sown grains in Norway showed an increase in yield on sprayed plots of 25.3 per cent above unsprayed plots. His yield increases were comparable on wheat, barley, and oats, and in all cases weed growth was reduced to a mere fraction of that on untreated plots. Sulphuric acid generally gave better results than harrowing, hand pulling, spraying with iron sulphate or nitric acid, or dusting with calcium cyanamide or other dry herbicides.

Meanwhile, there was developing in the humid sections of central and northern Europe a combined weed control and fertilization practice by means of dry-powdered chemicals. Kainite, a double salt of magnesium sulphate and potassium chloride with certain impurities,

was prepared in a finely powdered form for weed control. Where the soil was deficient in potash, this material was applied while the weeds were in the seedling stage. Under relatively high humidity that allowed for a slow action in solution, this material killed weeds and later, following rainfall, acted as a fertilizer to the crop. Calcium cyanamide is used in a like manner on nitrogen-deficient soils, and more recent work has shown that a mixture of calcium cyanamide and kainite at a ratio of 1:6 is superior to either alone. It should be borne in mind, however, that the profitable use of either of these depends upon both its herbicidal properties and its benefit as a fertilizer, so that mineral deficiencies of the soil must be taken into consideration in their use.

The selective action of the herbicides developed and used commercially during the latter part of the 19th Century, and the first four decades of the 20th Century, depended chiefly upon morphological differences between certain crop plants and weeds--such characteristics as nature of leaf surface, and position of growing points. With the discovery that certain synthetic growth-regulating substances had selective herbicidal action, there was ushered in a new era in weed control. The selective action of these herbicides was related to physiological differences of plant species, rather than morphological. Over a thousand organic compounds have been tested in this country and in England for growth-regulating activity on plants, and those showing high activity are indicated as promising for use as herbicides. The development of these synthetic selective weed killers dates back to the year 1940. And it is no exaggeration to say that certain of these compounds, chiefly, 2,4-dichlorophenoxyacetic acid, are the most important selective herbicides developed in the history of agriculture.

Their discovery has opened up an entirely new field of practical weed control. Moreover, their discovery has stimulated research along fundamental lines and encouraged us in the belief that synthetic substances may be found which will meet many different specific situations, involving various combinations of crop plants and weeds. Witness the recent development of isopropyl phenyl carbamate, phenyl mercuric acetate and salts of trichloroacetic acid, which are, however, still in the early experimental stages.

Not to be overlooked among the selective herbicides are the dinitro compounds such as sodium dinitro-orthocresylate, which was developed as a herbicide in France in 1933, and introduced into the United States in 1937 and the ammonium salt of dinitro-ortho-secondary-butylphenol, which came into use on a commercial scale soon after.

The use of oils and their fractions as selective weed killers is a relatively new development.

In short, there is now available in commercial quantities selective herbicides for use in the con-

trol of weeds in the following crop plants; all small cereals, including rice; in corn, milo, turfs, and pasturelands, in peas, flax, onions, garlic; in carrots, celery and other members of the Umbelliferae; in alfalfa, both seedling and established stands.

**SOIL STERILIZATION.**--The earliest tests designed to discover chemicals for sterilizing soils were those of Jones and Orton (1899) and of Stone (1909). They tested sodium chloride, copper sulfate and other salts, and finally settled on arsenicals as the most satisfactory. Soon, sodium arsenite became the standard weed killer of commerce. In this country and Europe the largest users of arsenicals have been the railroads. Chlorates, borax, and carbon bisulphide soon appeared as soil sterilants. Sodium chlorate has found its greatest use in the control of weeds along railroads in Germany, England, Australia, New Zealand, and the United States. Recently borax has been used extensively to combat Klamath weed. Various chlorate-borax and arsenic-chlorate mixtures have proved effective as soil sterilants. The efficacy of organic soil sterilants await further study. These have much promise.

**FORTIFYING AND ACTIVATING SUBSTANCES.**--In 1940, Hance, describing the use of herbicides in the cane plantations of Hawaii, reported the use of sodium pentachlorophenate as an activator and spreader in a number of common toxicants, which probably included sodium arsenite. This material, which is an excellent surface tension reducer and penetrator, increases the effectiveness of sodium arsenite. Ammonium sulfate and sodium sulfate greatly enhance the effectiveness of sodium dinitro-orthocresylate (Sinox). Recently, various dinitro compounds, pentachlorophenol and sulfur have been used extensively and effectively as fortifiers of oils. Also, quite recently reports indicate that certain constituents of onion juice increase the toxicity of 2,4-D. And, only in the last month, in Science (January 16, 1948) Mangual reports increase of herbicidal action of "Concentrate 40" by 2,4-D, and suggests that "2,4-D possibly activated the constituents in 'Concentrate 40' or vice versa, with a resulting synergistic reaction." (Concentrate 40 consists of 0.42% arsenic trioxide, 0.25% Santobrite-sodium pentachlorophenate and 0.25% sodium chlorate). Also similar results occurred when 2,4-D was added to oil emulsion fortified with "Santophen" (10% diesel oil fortified with 0.7% pentachlorophenol).

**LOW-VOLUME APPLICATION OF HERBICIDES.**--A spectacular development in weed control has been low volume applications. Whereas formerly we usually thought in terms of 100 to 300 gallons of liquid applied to an acre, we now are using successfully volumes as low as 3 gallons (or even less) per acre. Low volume applications have been made possible by improvements in equipment, particularly nozzles, and by taking advantage of the characteristics of 2,4-D and other hormonal herbicides. Low volume applications are especially

valuable in these small-grain areas where there is not a ready source of water and hence hauling and refilling add materially to the cost of application.

**PRE-EMERGENCE SPRAYS FOR WEED CONTROL.**--Considerable attention and emphasis have been given recently to the control of weeds in row crops by pre-emergence chemical treatments. Two methods of attack have been employed: (1) application of a selective herbicide to the soil at the time of seeding. The chemical in the soil kills weed seedlings, but those of crop plants are uninjured. In England, 2,4-D and related growth-regulating substances have been so employed to control broad-leaved weeds in cereal crops. (2) application of a general contact herbicide to a population of weed seedlings prior to the emergence of crop seedlings, or prior to the seedling of the crop. Under certain soil and weather conditions, slowly emerging seedlings, like those of onions, may be preceded by a dense stand of weed seedlings. It may be advantageous and economical to destroy this weed population by using a chemical which is lethal to all types of weeds, including grasses. The crop seedlings emerge and make their early growth free of weed competition. Moreover, the cost of hand weeding may be substantially reduced. Under other conditions it may be desirable to allow a crop of weeds to develop, drill the seed into the young weeds and then destroy the weed population before the crop seedlings emerge.

Pre-emergence weed control recognizes the fact that, as a rule, only those weed seeds that are within the upper one-fourth to one-half inch of soil germinate; and that if the initial population of weed seedlings is destroyed, without disturbing the soil and thus bringing more weed seeds near the surface, very few weeds will be present to interfere with the early growth of the seedlings of crop plants. Pre-emergence weed control also recognizes the fact that the early competition of weeds with crop seedlings is a factor of great significance; that the competition underground is quite likely more severe than that above ground; and that vigorous healthy development of crop seedlings is enhanced by the absence of this root competition.

If pre-emergence chemical weed control is to be of maximum benefit and economical, application of the materials must be made when the weeds are very small--from one quarter inch to one inch tall. At these stages the weeds are easily killed, the volume of materials required is low, and competition is eliminated early.

**MACHINERY AND EQUIPMENT.**--Brief mention was made of tillage implements. The development of spray and dusting equipment for the application of herbicides has been more spectacular and meteoric. The exhibits to be seen tomorrow at Davis will be striking evidence of this fact. There are marked improvements in pumps, booms, and particularly nozzles, adapted to both ground

rigs and airplanes. In all these developments the agricultural engineers have a wide-open opportunity and obligation.

**SUMMARY.**--A study of the history and development of weed control leads me, in conclusion, to the following observations.

(1) The greatest progress has been made in chemical methods of control. In this field, the discovery and use of selective herbicides rank first; herbicidal growth-regulating substances are the most noteworthy. Following closely in importance are the improvements in general contact herbicides, in fortifying and activating substances, and in soil sterilants.

(2) Marked and rapid advancement has been made in machinery and equipment for the application of herbicides. Of particular significance is the development of equipment and materials which permit of low-volume applications.

(3) Satisfactory progress has been made in the control of any one specific noxious weed or type of infestation only when special and direct attention was given to it bringing to bear on the problem fundamental biological studies covering every aspect. These called for the services of plant physiologists, plant morphologists, chemists, agronomists, and agricultural engineers. Striking examples of this approach are the bindweed project of the U.S. Department of Agriculture, and the camelthorn, artichoke thistle, and Austrian fieldcress eradication projects conducted by the California State Department of Agriculture.

(4) There is a tendency to over-play chemical methods of weed control and not give due attention to cultural, cropping, and other non-chemical means, or combinations of the two general methods.

(5) We have sadly neglected the educational phases of weed control; this pertains to resident instruction in colleges of agriculture and to extension departments.

(6) We have learned that the grower needs to know more than the *names* of the weeds if he is to practice economical weed control. In the past the majority of the weed bulletins and circulars dealt chiefly with species identification.

(7) Agriculture in this country is rapidly becoming mechanized. Agriculture is big business. Costs of production studies are of increasing concern. Analyses of the factors which enter into the production of a unit of food are being made with the same care as are those which are considered by the manufacturer of a non-living item. Seemingly overnight, weeds have emerged as a major factor in food production.

(8) As weed men we must convince, if that be necessary, our directors of Experiment Stations, and all others who dispense agricultural research funds, of the need for weed research, for basic biological investigations bearing on weed control, and for facilities and personnel required to carry on, and to a practical conclusion, such projects.

## RECENT DEVELOPMENTS IN HERBICIDES

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The topic "recent developments in herbicides" is in some respects similar to the "new look" in feminine fashions. An objective contemplation of either subject reveals some vaguely reminiscent features. Weed investigators occasionally succumb to fashions in weed control just as women give in to the dictates of fashion designers, often contrary to their better judgment. It would be exceedingly presumptuous and inaccurate to say that 2,4-D is a fad or fashion but there are variations in its use which sometimes assume fashionable symptoms. In 1946 most people wanted to get on the ester bandwagon but subsequent injury to grain crops caused some enthusiastic followers to make a strategic withdrawal. Signs of an incipient fad in the field of low volume spraying appeared in 1946 and flourished in 1947. It doesn't require a crystal ball to predict that pre-emergence treatments will get much attention in 1948.

This is not an attempt to discredit those materials and methods which have earned a proper place in the field of weed control. Instead it is a plea to look at new developments with the proper perspective in relation to established practices. It would be wise to examine developments critically and evaluate them in relation to standard practices at our disposal. The desire of people to be on the winning side sometimes leads to the unjustified use of some chemicals and to the discarding of others without sufficiently exhaustive examination of their true potentialities. 2,4,5 trichlorophenoxyacetic acid is perhaps a good example of the latter although there has been a revival of interest in 2,4,5 trichlorophenoxyacetic acid because of its superior results on some woody species. IPC has been summarily dismissed in some quarters simply because it failed to live up to some of the early claims for it. It is unfortunate that clean cultivation of "shoot cutting" has been so de-emphasized that it no longer receives the recognition it deserves in perennial weed control programs. The method is laborious and far from glamorous but very effective and I speak from personal knowledge in this case. Nevertheless it has been completely overshadowed in recent years by chemical control methods or "pill farming" if you will.

In this connection it is pertinent to note that the direct assault in science is sometimes the least successful. While it is legitimate to keep searching for curative agents for weed pests it is quite certain in the long run that more will be gained by broadening the base of fundamental knowledge of weed behavior. This somewhat tedious spade work is now moving forward

slowly in Beltsville and in other research institutions supported by public and private funds. Some of the fundamental projects have a beautiful simplicity in their conception and execution. Radio-active isotopes of known or possible herbicidal content are being allowed to distribute themselves through plants then tissues are assayed with Geiger counters and other improved physical and chemical apparatus. Instead of empirical tests with as many herbicides as facilities will permit would it not be of greater significance in the long run to know that the molecular configuration of a chemical compound is a clue to its herbicidal properties?

To seek blindly one shot cures without a basic understanding of plant behavior and chemical structure is like trying to design a supersonic airplane without a high-velocity wind tunnel. We must have the proper facilities and the know-how. When substantial progress can be reported in fundamental knowledge a vista will open up that is truly inspiring to think about, however wishful thinking and future schemes are not going to kill any weeds now.

It makes the "cut-and-try" weed man weary even to anticipate the task which is ahead of him when he stops to consider the literally thousands of organic compounds possessing theoretical herbicidal properties. Weed investigators are sometimes forced by circumstances to be opportunists. They are relatively few in number in comparison with the magnitude of the problem, they are widely dispersed and have significant gaps in their ranks when you consider the weed problem on a national basis. One of the aims of the Department of Agriculture is to assist in plugging some of those gaps just as quickly as possible.

A relatively small group of scientists have considered the basic weed control problems from the standpoint of deductive reasoning, while a much larger group approached the problem from the imperfect inductive or empirical viewpoint. They have not yet reached common ground. Nevertheless a proper place exists for each approach. Empirical investigations have produced most of our present information on weed control practices and have been the source of new developments which I will discuss today.

The cosmopolitan tastes of weed investigators make a thorough survey of the field rather difficult. The search for a grass specific goes on. I hardly need to remind you that the task is intricate and difficult to find a chemical compound which will migrate preferentially to growing points of grasses, and I might add parenthetically, to weedy grasses only. The question of toxicity or selectivity is being increasingly recognized as a relative matter. Modified by external and internal characteristics such as dosage, growth stage, and many other factors. Two classes of compounds are being energetically tagged and tested for grass control. They are contact ("knockdown") killers and systemic poisons.

Oils are being considered from the standpoint of selective sprays and as general weed killers. The range of petroleum products is limited only by the number of manufacturers. Oil specifications are those required by law or those established by the manufacturer in an attempt to standardise their own products. No weed killing specifications have yet been established for petroleum products and consequently there is apt to be confusion among investigators when discussing the merits of oil sprays. The paraffin-base crude oils found in the Eastern United States have different physical and chemical characteristics than the asphalt-base oils found in the Central and Far West. Diesel oil, stove oil, bunker oil, smudge pot oil, Stoddards solvent and various other fractions have been used from time to time in weed killing practices. Most weed experts agree that the percent and nature of the aromatic content of the oils are significant characteristics in determining their effectiveness as selective or general weed killers but not the only ones. Selectivity entails a quantitative relation between dosage, chemical composition, and certain unknown physical characteristics of plant tissue. Crafts of California has made important contributions in oil herbicides. Results from diesel oil used as a weed killer have changed somewhat from the initial observations made a few years ago.

Modern high-speed diesel engines require a different type of fuel than the older models and oil companies have kept abreast of fuel demands. Improvements in its fuel characteristics have coincided with a deterioration of its weed killing properties. C-tane rating is an efficiency index applied to diesel fuel just as the familiar Octane rating is applied to gasoline. Good diesel fuels are low in aromatic content which can be reduced by treating petroleum fractions with sulfur dioxide and in other ways. On the other hand, high octane gasoline used in airplanes is high in aromatics. Nobody in his right mind would seriously advise the use of gasoline for weed control. The low boiling range and flash point make this material too dangerous to use even though it might be a good weed killer.

Some oil companies are actively discouraging the use of diesel oil for weed killing purposes because it is in short supply and other special fractions are more efficient for the purpose. This information hasn't been too well distributed and diesel oil is commonly used for weed control in the west and southwest because it is almost universally available. For weed killing purposes we should look to the aromatic fractions which, in a sense, are by-products of petroleum distillation.

For selective spraying a light fraction, above API 38, which will evaporate quickly without leaving an objectionable petroleum taste is desired for use on carrots and other vegetable crops. Stoddards solvent, a dry-cleaning naphtha, was first used by vegetable

growers for selective spraying in the Long Island area. Some oil companies were puzzled by the excessive demands from distributors for dry cleaning fluid and upon investigating found that farmers were using the material for vegetable spraying. Several commercial products of this general type are now available including Gulf H.S., Sovarsol, Varsol, Sun Spirits, Shell No. 10, and Standard No. 1.

Most oil sprays can be applied with conventional spray equipment but some of the aromatics attack neoprene hose. Use of plastic hoses or frequent replacement of synthetic rubber hoses is necessary in this case.

Non selective weed killing oils sometimes cause minor discomfort to the applicator. Most common symptoms are a faint transient (erythema) reddening of the epidermis followed by eventual (desquamation) shedding of the epidermis resulting from prolonged exposure and intimate contact with the oil itself. Individuals vary considerably in their reaction ranging from no response to serious consequences from (episodic) blistering applications. In most cases the symptoms can largely be avoided by proper personal hygiene which includes frequent and thorough washing of exposed skin surfaces with Palmolive or other similar bland types of soap which restore the natural skin oils that are removed by contact with aromatic oils. Unfortunately not all compounds are as innocuous as 2,4-D but even in this case we find certain individuals who are sensitive to phenol injury which is often expressed in a bleaching effect on the skin and a prematurely wrinkled appearance.

Attempts have been made, with considerable success to activate or increase the toxicity of oils by the addition of other chemical compounds. There is evidence that this is activation not merely an additive effect. Pentachlorophenol and salt derivatives of this material have a toxic effect on plant tissue and when added to oils have a tendency to increase the toxicity of the oils themselves. Di-nitro phenols have a similar effect and are used either with or without water to act as extenders of oil sprays. The addition of water and an emulsifier to aromatic oils will often give a better coverage and dispersion of oil by wetting the dust film which occurs on vegetation. Heavy initial applications are apparently desirable on Johnson grass and other tough perennial grasses since an excess of oil applied to the foliage will creep into the crowns and do permanent damage to the growing point of grasses from which new growth emerges. Lower rates of application will destroy the foliage but will be followed by quick recovery.

When using oil-water emulsions fortified by dinitro compounds the water simply serves to get more complete coverage of the foliage. The emulsion breaks, the oil clings to the plant tissue, and the water runs off. Moderately stable emulsions are desired in the spray



tank to permit uniform distribution of the toxicant but if the emulsion is so stable that it runs off the leaves a serious loss in toxic effect may result. The addition of electrolytic agents like aluminum sulfate offers at least a theoretical advantage by producing a quick-breaking emulsion.

Johnson grass and Bermuda grass were more effectively controlled by Shell Oil Weedkiller No. 20 and General Petroleum Aromatic No. 4 in Arizona last summer than by any other materials tested. Five hundred gallons per acre applied in four treatments spaced four weeks apart eliminated both of these grasses from irrigation ditch banks.

Another chemical which has aroused considerable interest among weed investigators seeking a grass killer is ammonium trichloroacetate, hereafter referred to as ATA. Other salts and esters of trichloroacetic acid have also been tried but there is more evidence available on the ammonium salt than on other forms. Bruns at Prosser reported 90% injury to quackgrass foliage with applications of ATA at the rate of 110 pounds per acre. Willard of Ohio reported excellent results on quackgrass with 200 pounds per acre. Bruns reported that alfalfa and vetch were severely injured but recovered. These applications were made in a peach orchard and no injury to the trees was observed. Bruns also reported encouraging results with ATA on cattails. Timmons observed a considerable degree of selectivity in ATA applied at Hays, Kansas, and suggests that applications of this material at rates from 160 to 220 pounds per acre will give satisfactory control of Bermuda grass and Johnson grass. Note that this is about half the rate of application usually required with sodium chlorate. Estimates of comparative costs are impossible at this time because a price on the basic chemical has not been fixed.

ATA will be available in dry salt form for more extensive testing in 1948. Results during 1947 have been poorer on nut grass than on true grass species. Ryker has obtained some evidence of translocation of the chemical in tests with Johnson grass seedlings in Louisiana. The material is absorbed both through the leaves and through the roots. It did not prove satisfactory on mature Johnson grass on dry ditch-banks in Arizona but gave complete control of annual grasses which appear after cotton is laid by. The injury to cotton leaves from knapsack applications was of no consequence. The DuPont Company has taken a "go slow" attitude on this material and will not release it commercially during 1948. Less is known about the sodium salt form of trichloroacetic acid but one report from Hawaii indicates successful grass control without injury to most broad-leaved plants.

Pentachlorophenol has been used extensively as a wood preservative but it has been put to some relatively new and interesting weed killing uses recently. In the Hawaiian Islands sodium pentachlorophenate

is used extensively by pineapple growers for weed control in their plantations. Applications at the rate of 25 pounds per acre are made when the weeds are less than an inch high. All weeds, grasses included, are controlled without injury to the pineapple. Two months later a second application is made at the rate of 10 pounds per acre. Pineapples are sensitive to 2,4-D applied to the foliage--small amounts will induce premature flowering--but they are very tolerant to sodium pentachlorophenate. This chemical has a depressing effect on nitrifying bacteria in the soil and by regulating but not destroying these bacteria more immediate plant response is obtained from ammonium sulfate applied as a fertilizer. On the other hand, 2,4-D is used to kill the matured plants and cause them to assume a prostrate habit after the pineapples are harvested. The removal of 100 tons of green foliage per acre after the crop is harvested is an expensive and laborious operation but by using 2,4-D it can be knocked down and used in lieu of normal paper mulch for subsequent crops. New plantings are made in the old rows without injury because the roots of the pineapple plant are fairly tolerant to any 2,4-D residue which may be in the soil. The use of growth regulating substances and other chemicals has probably reached a higher stage of perfection in pineapple production than in any other crop. This has made successful competition possible with production areas located nearer the market and benefiting from the use of cheaper labor.

Sodium pentachlorophenate has been used successfully on a limited scale for weed killing purposes in this country. It appears to have a bright future when we learn more about how to use it.

Ammonium thiocyanate, whose herbicidal properties have been known for many years is now a subject of renewed interest in the search for a potato-top killer and cotton defoliants.

Sodium isopropyl xanthate, recently announced by the B. F. Goodrich Company is a non-selective water soluble herbicide which may also be used in the dust form. Test applications in concentrations ranging from 0.5 to 1.5 per cent have been made to vegetable crops in northeastern United States. It is usually applied between the rows, not as a top spray, and it is claimed there is no damage from drift. Two treatments are required to maintain a weed free condition. The material is claimed to be non-irritating, non-corrosive and not to leave a deleterious effect in the soil from applications made at rate of 100 to 150 gallons per acre.

Allyl chlorophenyl carbonate is another Goodrich product showing promise for control on crab grass, cereal grasses, cattail, burdock, Canada thistle and stinging nettle. This material is a growth inhibitor and there may be no external manifestations of injury but merely a necrosis of the inner tissues or stunting of the entire plant.

The life of weed control experts was made a little more hectic last spring by frenetic commercial and newspaper publicity which followed the announcement from the Rhode Island Experiment Station that phenyl mercuric acetate soluble (PMAS, for short) applied to soil as a fungicide also controlled crabgrass seedlings in creeping bentgrass putting greens. De France reported good control of seedlings from 7 applications of this mercury product called TAT-C-LECT made at the rate of 1 pint of concentrate per 100 gallons of water and applied at the rate of 10 gallons per 1000 square feet. At current prices this would be roughly equivalent to \$40 per acre for material. Puraturf and Puratized 806, also mercurial compounds, gave good control of crabgrass seedlings too. The rush in inquiries following the simple announcement in the Greenskeepers' Reporter in February 1947 is a good criterion of the intense interest in improved grass killers particularly from the standpoint of the average homeowner and others interested in weed control in turf situations.

An example of new uses for an old chemical is the attention that calcium cyanamid is receiving for weed control in vegetables and pre-emergence treatment for corn. This compound has many of the multiple purpose characteristics which are the ideal requirements in any herbicide. It has a selective toxic effect on young plants, is useful in disease control, and breaks down in the soil to become a nitrogen fertilizer. Pulverized calcium cyanamid has been used in the dust form as a weed killer in small grains and in pea fields. More recently this material has been used to defoliate cotton, soybeans, and tomatoes and to kill potato vines prior to harvest. Its use is now being extended to pre-emergent treatment of corn, onions, and asparagus fields.

Since the calcium cyanamid requires the presence of moisture for activation, the development of soluble derivatives of cyanamid seemed desirable for use as a spray in dry seasons and in areas where dews are infrequent. Two such compounds are now available, both water soluble. One is AERO Cyanate Weedkiller which contains potassium cyanate as the active ingredient. In general, a 1.0% spray solution applied at the rate of 80 gallons per acre to small onions, increasing to 2 or 3% in older onions gives satisfactory weed control. The other is sodium acid cyanamid which contains over 30% nitrogen and may be formulated for either sprays or dusts. It is somewhat hygroscopic and therefore is active whether or not dews are present. Approximately 25 pounds per acre have been found adequate for most annual weeds. The material is slightly irritating because of an excess of alkali and is corrosive to some metals.

Important developments in the field of aquatic herbicides have been made during 1947. Mr. John Shaw of the Bureau of Reclamation will give you a more complete account of these advancements but I will mention

briefly some of them. Bruns reported favorable results on pondweeds using copper sulfate. Introduction of a saturated solution into a canal at a rate sufficient to give a calculated concentration of 200 parts per million removed about 85% of the visible growth of *Potamogeton pectinatus*. *P. richardsonii* appeared to be slightly more resistant to copper sulfate. A second application was made later in the season. Roots were apparently little affected and would reinfest the canals rather quickly. Similar applications to canal water in Arizona containing 5000 ppm of soluble salts had practically no effect on any aquatic species. This may be partially explained by the precipitation of the copper sulfate as insoluble calcium sulfate. The simultaneous introduction of sufficient concentrated sulfuric acid to neutralize the soluble salts did not materially increase the effect of the treatment but it did prevent formation of a visible precipitate in the bottom of the canal.

Naphtha oil fractions with suitable emulsifying agents gave excellent control of aquatic weeds considerably cheaper than chemical methods now in use.

"Germ-I-Tol 100%," a quaternary ammonium compound is being considered as a herbicide where injury to fish is a limiting factor in the use of aquatic herbicides of the naphtha or benzene group. This material is supposedly non-toxic to fish but it is somewhat more expensive and details of dosage, etc have not yet been worked out. Orthodichlorobenzene compounds with added ingredients to assure an excess of stable chlorine holds promise of more consistent results than have been obtained in the past by this group of compounds.

It would be an oversight in any discussion on the subject of recent developments in herbicides to fail to note some of the advancements and improvements in the technic of application. The development and widespread acceptance of low-volume application of 2,4-D in the short span of one year is little short of phenomenal. It won't be necessary for me to go into any details on this subject because tomorrow you will see a demonstration of several types of new equipment now available.

The use of the pre-emergence principle may solve many weed problems which have been difficult because of the sensitivity of the crop to foliage applications of 2,4-D or other chemicals. At the moment, it has been most successfully employed with large seeded crops. The herbicide is applied just before the crop seedlings emerge and after the weeds have started. Deep planting will allow the crop seed to germinate and develop in a layer not affected by surface application of the herbicide. Another form of pre-emergence practice consists of fitting the seed bed in the normal manner, waiting until the weeds have emerged, spraying the weed growth, and then planting the crop with special knife-like tools which disturb the soil just as little as possible.

## THE BUREAU OF RECLAMATION'S PART IN THE CONTROL OF WEEDS ON IRRIGATION PROJECTS

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Leonard has found that dinitro compounds in the surface layer of the soil may cause death of several cell layers of crop seedling hypocotyls without visible permanent effect on the plant. The same degree of injury to a pigweed or crabgrass seedling may be lethal.

Both grass and broadleaved weed seedlings will be killed by pre-emergent treatments. Heavier applications of 2,4-D are required for pre-emergent treatments than for foliage sprays but relatively lighter dosages should be used on sandy type soils than on clay soils to minimize the danger to the crop seedlings. Di-nitros and oils have been successfully used for pre-emergence weeding in sugar beets and cotton and 2,4-D has been used in corn, soybeans, lima beans and some other vegetable crops. The surface soil must be carefully smoothed and be free of clods to insure a tight blanket around the crop seed. The seed must be planted more deeply than usual.

Something new and different has been reported by Bonner and Gray of Cal-Tech. Brittle bush exudes a substance toxic to surrounding plants according to these workers. This chemical has been isolated and synthesized and labeled AMB. Applications to tomatoes, peppers, and corn plants retarded their growth. Heavier doses killed the plants. The chemical had no effect on barley, oats, and sunflower. Just what use can be made of this discovery remains a matter of conjecture but it is at least an engaging possibility.

The inexpensive control methods developed by Savage and Harlan for mesquite and other range plants is certainly worthy of mention here. The formula used consisted of 1# 2,4-D acid, 0.6# sodium carbonate, 1 gallon diesel oil, and 4 gallons of water applied by plane at a total cost of \$2.00 per acre.

Leonard and Arle have reported good results on nut-grass using ethylene dibromide and chloropicrin as soil fumigants.

Dunham has reported a wide range of varietal susceptibility in flax. He found that 2,4-D has an adverse effect on oil quality and iodine number as well as yield.

No claim is made that the foregoing report has dealt with all the recent developments in herbicides. There have probably been many significant advancements of which no mention has been made here.

I would like to conclude this report with a word of caution. We have in effect "got a bear by the tail". Entomologists are becoming seriously disturbed over secondary and sometimes insidious effects of their new insecticides which upset nature's balance in the insect population in local areas. The time has come for us to make a critical inventory of our accomplishments and chart our future course. To paraphrase the words of Benjamin Franklin, "let us make haste slowly".

It is certainly a pleasure to be present at another Western Weed Control Conference. To anyone interested in weed control the outstanding event of the year is the privilege of attending your meetings where much valuable information is obtained concerning latest developments. This is about the seventh which I have attended and I am sure that the knowledge gained at each has helped the Bureau of Reclamation formulate a better and more economic weed control program.

While the Bureau has always felt an obligation to the Conference, at this, its tenth annual meeting it extends special greetings and wishes for success and it sincerely commends all of those who have made the meetings possible and so worthwhile. Special praise certainly is due to Walt Ball who has worked so faithfully and unselfishly in his duties as Secretary of the organization since its very beginning. When I say this I am certain that I am also voicing the opinion and sentiments of all Federal Agencies which have taken advantage of your fine annual conferences.

Mr. Moran, Chief of our Chemical Laboratory in Denver is representing the Bureau with his paper on the research program being conducted cooperatively with the Bureau of Plant Industry, Soils and Agricultural Engineering. However, Walt has asked me to say a few words regarding the Bureau's weed program so I will read some material which was prepared for other purposes. The data concerning losses due to weeds sustained by irrigation districts may be of particular interest to you.

In keeping with the greater realization that the United States, as a nation must give more thought to its natural resources--of which land and water are its greatest--the Bureau of Reclamation has inaugurated a weed control program designed to give more efficient use of its crop land and to largely prevent those water losses which can be attributed to weed growths, and at the same time to reduce its operation and maintenance costs. Weeds on irrigation projects definitely deplete land and water resources and create one of the major operating problems on farm lands and irrigation canal banks and channels where conditions for the growth of weeds are particularly favorable.

In the past, temporary but costly methods were used

because little scientific research had been conducted on irrigation problems. Recent studies, made possible through decentralization, are bringing a greater appreciation of the urgent need to solve weed problems more economically. The resultant control program is now showing results with excellent prospects of increasing the savings many fold. Definite steps have been taken to determine which of the widely varied methods of control are the most economic, to improve these methods and, if possible, to find new ones which would be even more effective. Particular attention has been given to weeds on canal systems because the control of such growths is the direct responsibility of irrigation projects.

No actual weed control work is done by Bureau forces on private farm land which is the responsibility of the farmers or weed districts. However, advice is given to project farmers on most effective methods of control and prevention through educational programs always conducted in cooperation with Federal, State and County agencies interested in weed control. Conferences are held with other weed leaders to determine how the Bureau can best cooperate with them and coordinate the program to prevent duplication. Very close cooperation is also maintained between the Bureau and every State college in the West from which mutual benefits are derived.

The realization of the need for more basic scientific research led to an agreement with the Department of Agriculture to conduct such research on irrigation weed problems for which the 79th Congress made a small appropriation to that Department. This work is well underway in three field stations and in the Denver Chemical Laboratory and the best of relations exist with the Bureau of Plant Industry, Soils and Agricultural Engineering which is conducting the investigations. While certain reclamation facilities are used in the research program the findings are being made available to private and Federal projects alike.

These seven regions of the Bureau are now compiling data obtained during the year 1947 from economic studies designed to give more definite knowledge concerning the losses sustained due to weeds and costs for weed control on irrigation systems.

From five average operating projects which have reported the results of the studies so far the records show that they have spent a total of \$71,204 in 1947 for controlling weeds growing on ditchbanks. The costs for dredging waterweeds (commonly called moss) and the silt they have deposited in canal, lateral and drain channels have been \$36,810 for the same period. This figure does not include chaining and chemical removal of waterweeds. The projects reported that an average of only 42 per cent of the weed control needed to be done was accomplished because of lack of funds or personnel.

The records show that last year through transpir-

ation, evaporation and seepage attributed directly to weed growths in channels and on ditchbanks there were losses totaling 30,701 acre feet of water. At \$1.25 per acre foot the value of the water lost is \$39,389. Repairs to ditchbanks and damages to crops caused by ditchbreaks due to weed growths on these five irrigation projects totaled \$28,335. Thus it can be seen that the total costs and losses due to weeds on the five projects in one year has been about \$175,700.00 for field costs alone or approximately \$200,000 when chaining, chemicals, incidentals and overhead have been added. This averages approximately \$50 per mile of ditch right of way. Projecting this average to the canals built by the Bureau of Reclamation alone these costs and losses amount to about one million dollars.

The findings of the weed control research program being conducted cooperatively by the Bureau of Reclamation and Bureau of Plant Industry, Soils and Agricultural Engineering are made available to private as well as Federal irrigation districts. The 1940 census gives a total of 127,533.7 miles of canal on all irrigation projects, Federal and private in the United States. Assuming \$50 per mile the costs and losses attributed to weeds can be estimated at over 6 million dollars. It is safe to assume that there is an additional 2 million dollars in water losses, damages to crop land and spent for weed control on drain banks and in drain channels, bringing the national total to 8 million dollars annually. Projecting the estimated water losses created by weeds on Federal Reclamation projects to all irrigation in the United States we arrive at the approximate figure of 956,000 acre feet per year.

The Bureau of Reclamation has, through its research work and more efficient planning and administration of its weed control program, been able to point the way to more economical and permanent methods of weed control. If sufficient funds and personnel can be devoted to this important field there is every reason to believe that even more savings can be obtained as well as increasing to nearer 100 per cent of the work needed to be accomplished as compared to the estimated 42 per cent which is now being done.

It is estimated that eventually through an adequate program the water lost due to weed growths and the present costs for weed control on all irrigation systems can be reduced at least 50 per cent or a total saving of 4 million dollars per year. If one-half of the estimated water losses due to weeds can be saved there would be an additional 478,000 acre feet available for irrigation or sufficient water to deliver 3 acre feet to 157,000 acres of land.

The Bureau has already introduced on its projects a much more economical and permanent method for controlling ditchbank weeds such as annuals, noxious perennials and willows through the use of the new chemical 2,4-dichlorophenoxyacetic acid (2,4-D) which

RESEARCH PROGRAM  
BUREAU OF RECLAMATION LABORATORIES  
DENVER, COLORADO

W. T. Moran, Head, Chemical Engineering Section  
J. M. Shaw, Chemical Laboratory

has reduced the cost of control work perhaps 25 to 35 per cent. The finding, through the Bureau's research work, of a new chemical to combat submersed waterweeds in irrigation channels has reduced the cost for chemicals to less than one tenth as compared to those previously used. The introduction of more pasturing of ditchbanks by project farmers livestock and the seeding of ditchbanks to weed competing grasses is not only furnishing valuable auxiliary pasture but is reducing future weed control costs. The construction work on new projects is being planned in such a manner as to prevent weed infestation or materially facilitate and lessen the cost of future weed control activities.

These and other accomplishments being attained by the Bureau's program is changing weed control activities from costly, temporary and haphazard guess work to an orderly program based on economic, permanent and scientific methods.

The control program within the seven Bureau Regions is conducted by Regional Weed Control Specialists who are all in attendance here at your conference.

It may be wondered why so much stress has been placed on costs of weed control and losses sustained from weed growths on irrigation systems. However, if we were asked to choose which single factor has handicapped progress most in all weed control in the past, I believe most of us would agree that it has been lack of funds. When sufficient funds for attaining any useful purpose are not obtained, such conditions can usually be blamed to lack of interest by the public. In turn lack of interest is often due to the public's insufficient knowledge of the problem.

While great strides have been made in obtaining weed consciousness it is believed that even more progress could be made if counties and states would make more comprehensive economic weed studies on farm lands and publicize the results in terms of costs and losses attributed to weeds.

If it is believed that this is a sound analysis of one of our collective weed problems it is hoped that it's presentation will help stimulate such studies and that information is obtained which will increase public opinion in favor of allowing more money for research, extensive and active weed control work. Some States have already started studies of this kind. The Bureau will be glad to cooperate with other agencies in obtaining such information on Reclamation projects.

Again the Bureau of Reclamation wishes you every success in your conference meetings. I am certain that all of us will leave here with information and an inspiration that will help us give better service to the public.

At the last Western Weed Control Conference, held in Portland, Oregon, Bob Balcom, Chief Agronomist for the Bureau of Reclamation, and Mr. Kephart of the Bureau of Plant Industry, Beltsville, Maryland Station, briefly described a projected cooperative research program on weed control in process of being undertaken by the Bureau of Reclamation and the Bureau of Plant Industry. Mr. Shaw's and my discussion then may be considered as a follow-up report on some of the phases of the work involved in this program.

At the present time, weed control field activities are centralized in each of the seven regional offices of the Bureau of Reclamation in the person of the "Regional Weed Control Specialist".

Our weed control research activities are conducted as one of the many phases of applied research being carried out in the central engineering laboratories of our Chief Engineer in Denver, Colorado. In the Denver laboratories, the Bureau of Plant Industry has assigned a plant physiologist from their staff to work directly with our own Bureau personnel on the agreed-upon research program. In addition, the Bureau of Plant Industry has established three field stations located at Phoenix, Arizona; Meridian, Idaho; and Prosser, Washington. One important function of the field stations is to serve as a proving ground for the research findings from the cooperative work at Denver.

The part of the program conducted at Denver includes various investigations such as water weed control, soil sterilization, and toxicity studies of various chemical agents to crop plants. Our discussion will be principally devoted to research and development on water weed control.

**WATER WEED CONTROL**

One important phase of the overall weed problem, peculiarly related to irrigation practice is the question of the control of water weeds in irrigation facilities. Water weeds commonly known as Sago Pond Weed, Horned Pond Weed, Pond Weed, or merely as moss reduce the capacity of canal channels making it difficult to deliver sufficient irrigation water; their desilting action necessitates costly dredging; and when they raise the water level, the result is loss of water through increased evaporation and seepage, erosion damage to canal banks, and often costly ditch breaks. In addition, water weeds greatly impair the efficiency of drains and in this way contribute to the water logging of farm lands and the formation of alkaline deposits in the soil. Except for mechanical or manual methods of removing aquatic vegetation

from irrigation facilities, there has been available only one chemical which would kill this type of growth. The actual need has been for a material which would kill water weeds at a cost low enough to permit its use as a preventative measure.

In seeking such a material, the research group at Denver was able to develop a satisfactory screening technique which permitted testing a large number of various chemicals. Several species of water weeds *Potamogeton pectinatus*, *P. foliosus*, *P. filiformis*, *Zannichellia palustris*, *Anacharis canadensis*, and *Ceratophyllum demersum* were collected and propagated in circulating water in large glass tanks under fairly well controlled laboratory conditions. In addition, species were propagated in various porcelain crocks. The screening technique employed consisted in treating sections of stems, leaves, and bud ends of the various species of plants in beakers containing different concentrations of a specific chemical for a given interval of time and observing the physiological effects of the material on the plant tissues.

A detailed discussion of the number of materials tested and the concentrations employed is obviously beyond the scope of our discussion. A few of them however are of interest. The di-chloro-phenoxyacetic acid compounds (2,4-D) seemed to be quite ineffective; in fact, the acid and several of its water soluble salts would not effect a kill with exposures of several days in concentrations up to 5,000 parts per million. Some of the metallic salts of 2,4-D, notably that of copper, were toxic to water weeds but the killing action was undoubtedly due to the copper ion.

Inorganic compounds of copper gave a great deal of promise in the laboratory. Concentrations of 100 to 200 parts per million killed several species of *Potamogeton* after an exposure period of 1 hour. Carrying the laboratory work to the field Mr. L.S. Evans at the Phoenix Field Station treated two small canals with copper sulfate with discouraging results; while Mr. Bruns at the Prosser Field Station experienced good results in two tests. The failure at Phoenix and the success at Prosser can possibly be explained by the difference between the chemical characteristics of the waters in the two areas. The water in the canals treated near Phoenix was very high in alkalinity which rendered the copper sulfate insoluble by converting it to basic copper carbonate. The water encountered in the tests near Prosser was very low in alkalinity and contained very little material which would form insoluble compounds of copper.

Among the many materials investigated, it was discovered that certain of the fractions distilled from coal tar were very toxic to all species of water weeds which were available in the laboratory for testing. These portions of coal tar naphtha with boiling points in the range of Xylene and upwards were the most toxic. This finding was made in the following fashion:

In attempting to determine if 2,4-D or any of its derivatives or commercial formulations would effectively kill water weeds, it had already been ascertained that neither 2,4-D nor any of its salts were toxic to these types of weeds in concentrations low enough to permit their use on a cost basis. However, in using one particular commercial formulation containing only 5 per cent of a 2,4-D ester, it was found that water weeds were readily killed. In view of our experience with other 2,4-D compounds, it seemed apparent that the toxicity exhibited in this instance was due either to the "base" or "carrier", or "emulsifying agent". The manufacturer was contacted and a small amount of the "base" or "carrier" was supplied us. In all respects this sample was identical to the original formulation except that it contained no 2,4-D. Upon discovering that the "base" alone was quite toxic to water weeds, it was examined and fractionated by distillation. It proved to contain a large percentage of an aromatic material or materials which fell within the boiling range of Xylene. As many pure compounds derived from coal tar as it was possible to obtain were examined for toxicity with the result that many of them were found to be very toxic to water weeds, increasing in toxicity with the number of methyl substitutions on the benzene ring.

In addition to coal tar naphtha, numerous other materials were found to be effective water weed killers, at least in the laboratory. These included chlorinated aromatics, chlorinated phenols, chlorinated unsaturated straight chain compounds, and to a lesser degree the cresols and phenols. It was also found that D-D soil fumigant and carbon disulfide, when properly emulsified, were quite efficient water weed killers. For a material to use in a preliminary field test, light coal tar naphtha was chosen because the aromatic naphtha appeared the most toxic, and because they are readily available and low in cost.

#### FIELD TESTS USING AROMATIC SOLVENT NAPHTHAS--

The first field test was conducted in the Main Canal of the Riverside Irrigation Company near Fort Morgan, Colorado. Coal tar naphtha, to which was added 10 per cent by volume of emulsifying agents, was used. The emulsifier employed was a mixture of equal parts of mahogany soap and sulfonated castor oil. This mixture was introduced into the canal beneath the surface of the water through a spray nozzle with an orifice 0.02 inches in diameter at a pressure of 50 pounds per square inch. A small portable pump and motor unit was used to pump the chemical from drums into the canal. The canal, so treated, had a designed capacity of 300 cfs, but was so badly infested with *Zannichellia palustris* that maximum flow obtainable had been reduced by 50 per cent. A concentration of 136 parts per million of the emulsified naphtha was maintained for a period of 50 minutes. The treatment was very successful and

the full carrying capacity of the canal was restored within 72 hours.

The Yocum Ditch near Arvada, Colorado is a small one of 4 cfs capacity and was infested with a rank growth of *Potamogeton foliosus*. A concentration of 185 parts per million of the same type emulsified naphtha used in the first field trial was maintained for a period of 60 minutes. This test was also very successful and within 72 hours after treatment, the ditch was free of weeds for a distance of 1 mile below the point of application. As it was late in the season, it was felt that possibly the water weeds were entering their dormant stage, so the importance of this test was minimized.

In the latter part of November 1947, we conducted a series of field tests with the Imperial Irrigation District of California and on the Yuma and Gila Projects of the Bureau of Reclamation near Yuma, Arizona. Weed growth in the canals and drains was very luxuriant, most of it mature and in the seed-dropping stage. *Potamogeton pectinatus*, *Zannichellia palustris* and *Chara* sp. were the predominant types encountered.

The chemical mixture used in all tests was a commercial grade of Xylol. To this material was added 5 percent by volume of a sulfonated petroleum product commonly known as mahogany soap. Best results were obtained when particular pains were taken to thoroughly mix the two ingredients prior to use with continued rapid mechanical agitation during the time of treatment. Good mixing, pump pressure of 450 psi and small nozzle orifices all measurably increased the efficiency of the material by causing better dispersion in water, and in this way allowing the emulsion formed to be carried farther down stream before breaking and rising to the surface. All of the November field tests were eminently satisfactory, thus confirming laboratory tests as well as the earlier field trials, with the possible exception of the treatment of the "A" Canal of the Gila Project. In this case, a combination of factors, principally inadequate mixing of the ingredients, resulted in a rather weak kill of the weed growth present. Subsequent to these November field trials, we have been informally advised that the Palo Verde Irrigation District, Blythe, California have used emulsified naphtha very successfully.

### CONCLUSIONS AND RECOMMENDATIONS

Many chlorinated hydrocarbons and other compounds will kill water weeds, but nothing has yet been found that will compete with the aromatic solvent naphthas in availability, efficiency, and cost. Prices of acceptable materials range from 18 cents a gallon to 42 cents a gallon. Sufficient information is not yet available as to what effects this material will have on roots but it is believed that regrowth will occur to some extent after treatment.

In addition to killing aquatic weeds, this newly developed material has been found very toxic to fish,

crustacea, snails and mosquito larvae. Obviously the killing of fish is an undesirable feature. As an interesting side-light from water weed control, the matter of snail control might be touched upon for a moment. Although snail control is of minor importance in the United States, it is a problem of no little significance to other countries. Egypt is becoming concerned because many species of snail serve as reservoir hosts in the life cycle of numerous species of *Schistosoma* parasites (blood flukes, liver flukes, etc.). The disease caused by these parasites often reaches epidemic proportions along the Nile River. Inasmuch as the snail feeds on water weeds, control of the vegetation should reduce the snail population. In our field trials, the snails found in streams and irrigation canals in this country were even more susceptible to solvent naphtha than were water weeds, 25 to 50 parts per million seeming to be a lethal concentration. The Ministry of Health of the Egyptian Government has already asked for information on the possible use of our materials for the purpose of dual control of water weeds and snails.

A few words should be mentioned on safety precautions in handling this material. It is inflammable and should be kept away from open flames. Care should be taken to avoid excessive breathing of fumes arising from the naphthas. Prolonged or frequent contact of the liquid with the skin may cause a troublesome dermatitis. Naphtha can be removed from the body by thorough washing with soap and water.

Further studies on the toxicity of this material to crop plants are necessary. Preliminary laboratory studies do not indicate any adverse effects on plants beyond the seedling stage in the concentrations employed. Inasmuch as the naphthas are relatively volatile compounds, it is very doubtful if any residual effects in the soil would result from their use. It would however seem wise to avoid the use of irrigation waters, treated with emulsified naphthas, directly on crops and particularly where irrigation is by flooding.

Official publicity on the newly-developed material is contemplated in the March 1948 issue of the Reclamation Era. Detailed chemical and physical characteristics of the base material and types of emulsifying agents along with further detailed information on application is to be contained in this article. It is expected that sufficient reprints of the article will be made available for distribution to interested individuals. The Solicitor for the Department of Interior has already requested from the Attorney General a patent in the Government.

### ACKNOWLEDGMENTS

The authors wish to express their appreciation to the officials and operating personnel of the Imperial Irrigation District, Imperial, California; the Palo Verde Irrigation District, Blythe, California; the

Riverside Irrigation Company, Fort Morgan, Colorado the Yocum Ditch Company, Arvada, Colorado, for their splendid cooperation and help in making the field applications possible. We also wish to acknowledge the invaluable assistance of our colleagues of the Bureau of Plant Industry, Department of Agriculture, particularly to Dr R. S. Rosenfels who was an active participant in the Denver investigations; to Mr. John N. Spencer, Supervisor O & M, and Mr. John Maletic, Weed Specialist, Region 7, Denver, Colorado; and Mr. Curtis Bowser, Weed Specialist, Region 3, Boulder City, Nevada, for making the arrangements for our early field tests.

## BIOLOGICAL CONTROL OF KLAMATH WEED PROGRESS REPORT

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Chemical control of *Hypericum perforatum*, called Klamath weed in California, has had a long and interesting history. In most places the cost of materials and the inaccessibility of the lands to be treated have been limiting factors. Recently borax has been used to control new and small infestations and is highly recommended for this purpose by the various agencies engaged in weed-control programs.

Biological control of the Klamath weed by insects has been under consideration for several years as a desirable approach to the problem. In 1920 the Commonwealth of Australia began a search for insect enemies of *Hypericum* in England, according to a report by Currie and Garthside (1932). Early in 1935, after the introduced British species apparently had failed to become established in Australia, the work was transferred to southern France and the results of these studies were published by Wilson (1943). The preliminary work in Europe consisted of tests to determine whether a considerable number of insect species fed or reproduced on representative plants of economic importance--that is, on 42 widely distributed species belonging to 19 families.

After the satisfactory conclusion of the tests in Europe, the species that had neither fed nor reproduced upon the test plants were exported to Australia. Before liberations could be made there, however, it was necessary to make additional tests on plants that did not grow in Europe. The progress of the Australian experiment was followed in California with much interest. About 8 years after two species of *Chrysolina*, known as *hyperici* (Forst.) and *gemellata* Rossi had

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been released in Australia, encouraging results were reported by A. J. Nicholson, in correspondence with Harry S. Smith, of the University of California, College of Agriculture. Negotiations between the University of California and the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, regarding the advisability of introducing the beetles into California resulted in an authorization by the Department to import *Chrysolina hyperici*, *C. gemellata*, and *Agrilus hyperici* Creutzer, with the proviso that feeding tests be made on the following plants: Sugar beet, flax, hemp, sweet potato, tobacco, and cotton. A cooperative project for the importation, testing, and colonization of these species was then set up between the two organizations.

The second World War made it impossible to make collections in Europe. An abundance of material was available in Australia, however, and it could be transported to California by the U. S. Army Air Transport Command. The Australian Council for Scientific and Industrial Research, through Dr. Nicholson, offered to collect and ship the needed material. The collection and preparation of the insects for shipment was under the immediate supervision of T. G. Campbell, research officer of this Council.

Importations were begun in October 1944. The first problem was to change the life cycles so that they would be in phase with the seasons of the Northern Hemisphere. Specimens of *Agrilus hyperici* were received as mature larvae in roots. Some of the larvae were retarded in cold storage, but others were forced to emerge upon arrival. Since neither method gave satisfactory emergence of adults, further importations were curtailed until the Bureau laboratory in Europe could be reopened. Material was subsequently received during 1947. Starvation tests have been completed, but no liberations are to be made until after the distribution and effectiveness of the two leaf-feeding species has been studied.

The two species of *Chrysolina* were occasionally shipped as mature larvae that would emerge as adults upon arrival, feed, and enter aestivation about 3 weeks later. Most of the shipments, however, consisted of aestivating adults. In either case the problem was to bring the adults out of aestivation into the egg laying phase. By subjecting the adults to fine sprays of water each day, fertile eggs were obtained within 2 to 3 weeks.

In 1944 sufficient specimens of *Chrysolina hyperici* were received for conducting the feeding tests. The tests were completed in May 1945, no feeding or egg laying having taken place on any of the test plants, and four colonies were released late in the season. One colony became established, but the survivors were so few that it was not possible to make recoveries until 1947.

Approximately 370,000 adults of *Chrysolina hyperici* were liberated from 1945 through 1947. Of this number, 3500 were reared in the insectary. Insectary



rearing presents a difficult problem, because there are several generations of common greenhouse pests to one of *C. hyperici*. Small-scale rearing can be handled by placing larvae on fumigated *Hypericum* plants and transferring them to fresh plants once or twice during the feeding period, but such a procedure is costly and is not suited to an extensive program.

Liberations of *Chrysolina hyperici* prior to 1947 had been made in nine different colony sites distributed among five counties in California. Seven of the nine colonies have become established, and already in two locations complete destruction of Klamath weed is evident within a radius of 15 yards around the original release locations.

During 1947 releases were made in 12 additional counties in California, making a total of 66 new colonies, and 2 experimental colonies were started in Oregon. It is hoped that these releases will furnish each county with colonies which can later be used as a source of material for local distribution.

The feeding tests with *Chrysolina gemellata* were completed on January 26, 1946. A total of 13,650 adults of this species were released in four counties. Releases were made in February 1946 from imported material that had been received during the preceding two months. All the colonies became established, and large increases were noted before the first generation was completed. During the second season, 1946-47, two of the colonies did exceptionally well. At the time of their emergence in April and May 1947 the adults could be found readily a quarter of a mile from the point of release.

During the winter of this second season the destruction of the basal growth of Klamath Weed by the larvae was very apparent, and the results of this feeding were evident on new upright spring growth. In the areas of little larval feeding each plant had four or five uprights, whereas in the heavily infested areas the upright growth ranged from none to two small stems. The emerging adults stripped the remaining one or two stems of all their leaves, and an area several yards in diameter is now devoid of any living weed. At the present time the egg and larval populations are far in excess of those of the previous year.

The importations received during 1947 contained an estimated 5 per cent of *Chrysolina gemellata*. Releases were made in units of 5,000 beetles; therefore, each colony site of *C. HYPERICI* received approximately 250 *C. gemellata*. Past experience with this species indicates that this small number would be sufficient to start a colony should *C. hyperici* fail to become established in any location.

Briefly, the life history of the two species of *Chrysolina* is as follows: In the spring as the flower buds are forming the adults emerge. They feed voraciously on the leaves and tender stems of the plants.

A month or so later the plants become dry and unsuitable for food and the adults cease feeding and enter a period of aestivation. With the first fall rains procumbent basal growth commences. At this time the adults come out of aestivation and feed sparingly on the new foliage. After a week or two they mate and begin to lay eggs. The egg laying continues throughout the winter months. The rate of deposition and the duration of the egg and larval stages are dependent upon the temperature. All the larvae, regardless of hatching time, reach maturity in the spring, and pupation takes place at about the time the erect stems of Klamath weed are half grown. Adults of the new generation emerge as the buds are being formed, one life cycle being completed in a single year.

Some of the progeny of the now successful colonies will be used for liberation in more northern out-of-State locations as soon as collections can be made without depleting the mother colonies. It may be possible to start on a small scale this year. Materials collected and liberated in the last spring at about the time the beetles enter aestivation become synchronized with the plant growth more readily, as conditions which promote the basal growth in the fall also bring the beetles out of aestivation. As previously stated, it is possible to bring the imported adults out of aestivation the first year and have them in step with the seasons of the Northern Hemisphere. Under the best conditions, however, this cannot be accomplished until January, which means that the beetles are two or three months behind their normal egg-laying schedule. Therefore, the new colonies originating from importations do not increase so rapidly as those that are made up of beetles from colonies already in synchronization.

As soon as the distribution phase is completed the problem will then enter upon the control phase. At present it is difficult to formulate any exact ideas as to the outcome, but control is reported to be effective in Australia, and the two important species, *Chrysolina hyperici* and *C. gemellata*, have become established here. The progress of the work has been satisfactory, and the outlook for the future is good. However, it should be remembered that considerable time is required to evaluate a biological control program. Therefore, at present there should be no relaxation of the control programs which are being followed.

#### LITERATURE CITED

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- Wilson, Frank. 1943. The entomological control of St. Johnswort (*Hypericum perforatum* L.) with particular reference to the insect enemies of the weed in southern France. Austral. Council Sci. and Indus. Res., Bul. 169, 87 pp.

The session adjourned at 5:15 p.m.

Tuesday  
February 3, 1948

The program for Tuesday was held in Davis, California the forenoon being spent at the University Airport where airplane pest control operators exhibited and demonstrated their different types of equipment. This proved both interesting and educational to some 700 to 900 persons present. The Conference wishes to take this opportunity to thank C. Harold Hopkins and John C. Patterson of the University Airport for their wholehearted assistance and cooperation and for the use of the field. The Conference wishes also to thank each of the airplane operators for the time and expense they so willingly gave to make that portion of the program so successful. It was a most interesting demonstration.

Mr. Murray R. Pryor, Field Supervisor of Weed Control of the State Department of Agriculture, Sacramento, reports as follows:

The following airplane commercial pest control operators of California were represented at equipment day demonstration of the Western Weed Control Conference held at the University Airport of Davis: Weggers Airplane and Dusting Company, Woodland; Inland Aviation Company, Los Banos; Jensen Airplane Crop Dusters of Sacramento; Hawke Dusters, Modesto; Interstate Commercial Flyers, Davis; and Borgas Airplane Crop Dusters.

The equipment design and specifications are of particular interest, and represent the latest developments in this field. A list of specifications of each company represented is given in the following:

(1) Weggers Airplane and Dusting Company

Type Airplane: N3N

Engine: 300 H.P. Lycoming

Boom: Pierson boom full wing length, 34 nozzles in clusters of 4 or 5 with gas cock type shut-off valve for each cluster. Valves controlled by cable running back to cockpit.

Pump: Power take-off pump with check and V-Belt drive.

(2) Inland Aviation Company

Type airplane: Boeing

Engine: 450 H.P. Pratt and Whitney

Boom: Stearman boom full wing length, 24 nozzles singly placed on boom, liquid pressure operated nozzle with poppet style valve (designed by Stearman).

Pump: Electric motor driven pump with controlled discharge.

(3) Jensen Airplane Crop Dusters

Type airplane: N3N

Engine: 450 H.P. Pratt and Whitney

Spray applicator: Brush type, 4 units equally spaced under lower wing with an additional spout type applicator under fuselage. The brush units are circular brushes mounted on rotors, each driven by small propellor on front of rotor. Droplet size controlled by spacers between brushes.

Pump: None. Gravity feed to brushes. Valve at each brush provides immediate shut-off. Gallonage rate controlled by valve in cock-pit.

(4) Hawke Dusters

Type of airplane: N3N

Engine: 300 HP Lycoming

Boom: 24 nozzle full wing length boom with Spraying Systems Nozzles pressure controlled ball check type valve.

Pump: Outside pump driven by small propellor from main propellor slip stream.

(5) Interstate Commercial Flyers

Type of airplane: N3N

Engine: 450 H.P. engine

Boom: 30 nozzles on full wing length boom. Nozzles shut-off by gas cock valve, valves controlled by cable running back to cock pit.

Pump: Outside pump driven by small propellor from main propellor slip stream.

(6) Borgas Airplane Crop Dusters

Type of plane: Stearman

Engine: 450 H.P. Pratt and Whitney

Boom: Short boom, space for 66 nozzles. Monarch nozzles. Boom valve shut off.

Pump: Power take-off pump with 2 V-belts.

Afternoon Session

Tuesday, February 3, 1948

The afternoon session was held at Agricultural Engineering Building, University Farm, University of California, Davis California.

Here weed spraying and dusting equipment was exhibited and demonstrated. Nozzles were given special attention and were very well demonstrated by the Engineering Division. Materials used in weed control were also displayed.

The Conference wishes to thank Mr. J. P. Fairbank and his co-workers for the splendid job they did in arranging for and setting up this phase of the machinery and equipment program and for his remarks which follow:

REMARKS BY J. P. FAIREBANK  
DIVISION OF AGRICULTURAL ENGINEERING  
UNIVERSITY OF CALIFORNIA

The College of Agriculture is honored to have the equipment session of your Tenth Annual Meeting held here on the Davis Campus. We are indebted to the officers of your organization for scheduling a portion of your time here, and appreciate having so many of you spending the day with us. We hope you will come again.

In behalf of the local staff I wish to thank the many exhibitors for the time, effort, and expense they have used in displaying weed control equipment.

Furthermore we are indebted to C. Harold Hopkins, and John C. Patterson for the use of the University Airport and its facilities for the demonstration of the

spray planes:

We must not overlook the efforts of the equipment committee in making the local arrangements for the displays and demonstrations. These people who did all the work do not have their names in the program, in the papers, nor on the radio, but I want you to know who they are: Dick Raynor of Dow Corporation, Murray Pryor of the State Department of Agriculture, Bill Harvey of the Division of Botany and Norman Akesson of the Division of Agricultural Engineering University of California.

This forenoon you had the opportunity to see a number of spray planes in action and to examine the equipment. You saw ships which drove their liquid pumps by individual propellers; by veebelts from the aircraft engines; and one by an individual electric motor. You saw long booms and short booms; "streamlined" booms and round tubing; nozzles in clusters or in single units discharging at a variety of angles from the boom--front, rear or "quartering"; nozzles shut off by gang-controlled valves along the boom, or by master valves at the pump. You saw one ship which dispersed the liquid by revolving steel bristle brushes driven by individual propellers. In short the demonstration at the airfield showed that airplane spray equipment is far from being frozen into a single pattern--there is still a wide diversity of design.

On the railroad siding here at the Campus is the spray train exhibited by the Chipman and the Southern Pacific Companies to show us the equipment which is used to kill the weeds on hundreds of miles of railroads.

Here at Agricultural Engineering are displays of many makes of weed sprayers and equipment now commercially available. It is only just recently that equipment manufacturers have started to make complete weed sprayers ready for use. Back in the days when W. E. Ball and O. C. French worked on equipment for spraying grain fields with sulfuric acid, and when Westgate and Raynor published on Sinox, folks had to tuggle up their sprayers from odds and ends with the various units obtained from many different sources; and often not well suited to each other nor for the job to be done. Now with the great development in herbicides and the "snowballing" interest of the public the equipment manufacturers are well embarked in the development, construction and sales of complete machines to supply the current and potential demand, and that is good.

A casual glance at the greatest variety of equipment shows that the design of ground sprayers is still in a fluid state as are the airplanes. You can see here all types of pumps--plunger, rotary, centrifugal, regenerative turbine and flexible impeller in addition to the hydro-pneumatic system. You see many versions of boom mountings and adjustments; light metals as well as steel for tanks and for booms; pumps belted or direct connected to independent engines or to

power-take-offs on tractors and trucks; nozzles of many styles and sizes; rigs mounted on trailers with adjustable axles; on skids to be carried on pick-ups and mounted directly on tractors. We call to your attention the operating display of various nozzles on booms at our pump pits, where you can see a novel aspirating system to put suction on the boom to stop nozzle drip when the pressure is cut off.

Never before has there been a display like you see here today because last month some of the apparatus was not in existence. Moreover it is unlikely that you will ever again see a display just like this one, because by next year it is possible that some of the present equipment will be superseded by improved versions.

Here is a list of the exhibitors and the types of equipment they display. I am not sure that the list is entirely complete. If we have overlooked some exhibit please call the oversight to our attention.

#### EXHIBITORS

##### Airplanes - (At University Airport)

Borgas Flying Service, Clarksburg  
Hawke Dusters, Modesto  
Interstate Commercial Flyers, Davis  
Inland Aviation Co., Los Banos  
Weggors Airplane Seeding & Dusting Co., Woodland  
Jensen Crop Sprayers, Sacramento.

##### Weed Sprayers, Dusters and Equipment

Food Machinery Corp. with Central Valleys Spray Equip. Co.; Sacramento  
Three "Bean" Sprayers

Banta & Driscoll, Los Angeles  
Portable Sprayers and "HiFog" Gun

Pacific Implement and Tractor Co.; Richmond  
"Hydrospeed" Sprayer on Ford Tractor  
Gustafsen - Sprayer

Tuft & Co.; Anaheim  
"Tuft" Sprayer with Boom

Peter Vandenbosch, Stockton  
"Torpedo" Weed Control

Hurst Industries; San Jose  
Two "Robin" Sprayers with Booms

Mack General Weed Gun; Caldwell, Idaho  
Mack Weed Sprayer with boom, Portable

Pumping Unit and Soil Fumigant Injector

Livestock Sprayer Mfg. Co.; San Jose  
"Prodel" Sprayer

H. C. Shaw Co.; Stockton  
Two "Iron Age" Sprayers with Booms; One  
"Messinger" Duster

California Orchard Heater Co.; Pomona  
Three "Master" Sprayers; One Pumping Unit

Sherwin-Williams Co.; Research Div.; Oakland  
Spray Equipment mounted on John Deere  
Tractor

Essick Mfg. Co.; Los Angeles  
Three "Essick" Hydropneumatic Sprayers;  
misc. compressed air equipment

Jerome Simmer Co.; Minneapolis, Minn.  
"Simer" sprayer with aluminum tank and  
skids; one pumping unit

Pacific Pump & Supply Co.; San Francisco  
"Myers" Sprayer; skid mounted

Tehama County (By Steve Ancell, Agr. Commissioner)  
Lightweight portable spray unit for Klamath  
weed control

Henry T. Gage, Bell, California  
"Gage" sprayer with hand guns and boom

Naco Mfg. Co.; Huntington Park  
Two Naco Weed dusters with booms

Fabricated Metals Co.; Oakland  
"Spray Rite" Sprayer with boom; pumping  
units with aspirators

Jacuzzi Bros. Inc.; Berkeley  
"Jacuzzi" pumping unit

Floyd W. Brady, Los Altos  
"Flex Rotor" pumps

Jabsco Pump Co.; Burbank  
"Jabsco" pumps

Geo. S. Lacey Co.; San Francisco  
"Oberdorfer" pumps

W. P. Alexander, San Francisco  
Nozzles made by the Morley Co.

A. E. Garland, San Francisco  
Nozzles made by Delevan Mfg. Co.

Harang Engineering Co.; San Francisco  
Nozzles made by Spraying Systems Co.

Spray Engineering Co.; Somerville, Mass.  
Nozzles

W. A. Westgate, Davis  
Nozzles made by Monarch Mfg. Works

Chemical Weed Control Co.; Berkeley  
Spray Truck

#### Herbicides

Dow Chemical Co.

Dupont

Shell Oil Co.

Sherwin-Williams Co.

Standard Agricultural Chemicals

Vieth Chemical Company

Wednesday, February 4  
Morning Session

The meeting was called to order at 9:00 am by President Freed. Mr. Freed then called on Secretary Ball who made the following introductory remarks:

MR. BALL: In our state reports from year to year those of you who have been in attendance know that I have reported on railroad work that has been done in California primarily test work in an attempt to find some means of handling this problem.

We have with us today Mr. A. G. Perkins who is safety supervisor of the California Public Utilities Commission. I requested Mr. Perkins to take not over two or three minutes to tell you just what he has on his mind in respect to this railroad problem which we have, and everyone has a problem so far as railroad rights of way are concerned. Mr. Perkins, please.

MR. PERKINS: Thank you, Mr. Ball. It is a genuine pleasure, Delegates of the Western Weed Control Conference, to meet with you and to hear what has been said regarding the development in the control of the weeds which annually take from us many of the resources of our nation. I was particularly interested yesterday out at Davis to see the improvements that have been made in the methods of controlling growth of weeds. I was particularly interested in noting the improvement that had been made in the methods of dusting for weed control. Let me tell you something of how this dusting first commenced. I am quite sure that it commenced on the farm where I was reared; one of about 40 acres through which a transcontinental railroad operated and cut the farm in two. On our farm where I was a boy we raised the ordinary row crops, some hay and some grain and corn and cattle etc. and it was my painful duty to do a lot of the eliminating of the weeds with the old-fashioned hoe. While I would be hoeing corn or beans or whatever it was near the track, freight trains on the upgrade would pass at a slow rate of speed and I just couldn't resist knocking off for a few minutes and grabbing the freight, which a boy of my caliber at that time could do, and ride down a half mile or so to the old swimming hole where I would join my friends in a bath, but here's where the dusting commenced.

When I got back to the farm my father usually would be around there somewhere and would have inspected by that time the rows and the weeds that hadn't been cut and he would go to the nearby bank of the creek and procure a rather mature willow and that, gentlemen, is where the weed control by dusting actually began. It had the effects of eliminating a lot of weeds for a brief period after that, I assure you.

Now this method of weed control by dusting together with the cows that had to be milked and the woodpile and the other variables on the farm literally forced me to the right of way and on to the rails and it

has been my life's work on the rails ever since. During recent years I have worked for the State instead of working for one railroad and I now work for, or I should say with, more than fifty railroads in the State of California. Now this weed problem is certainly a problem to the railroads. First a railroad has an excuse for being one because it hauls freight and passengers and when the production of your fields and your ranges are reduced they suffer loss along with you. I don't know but that it would have to be a pretty good size city or industrial area before the railroads would lose their place as about the best neighbors and the biggest industry in the town. Speaking for all of them I assure you that they are eager to cooperate with you in the control of these weeds because it certainly is a problem with them; not only does it affect the volume of traffic and their revenues but it clogs their ditch banks as well as it clogs yours. It presents to them a definite fire hazard and they find it necessary to not only control weeds but to completely sterilize the ground upon which they pile their ties and their timbers and the other equipment and materials which they use. So their's is the job of determining what will sterilize certain of the ground. Then of course, they want to be good neighbors with those who live along their tracks and they endeavor to control the growth and spread of weeds very genuinely and spend a lot of money in that direction each year. Even though there are locations where you think the railroads don't care much about weed control, I assure you that the top management of railroads throughout the country are eager to work with you and cooperate with you in this direction.

Now, there is another factor that you are perhaps very much unacquainted with and that is this thing of safety. What does weeds have to do with safety? I am sure you would be much surprised if you knew the number of men in the maintenance department and in train service that receive serious injury each year when they are scratched with weeds, particularly we have in this country the star thistle. It is a definite problem to no end of train men who get off into the night time into these star thistles along paths where they have to walk and between the tracks and they receive personal injuries to the degree that the appropriate representatives of the Brotherhoods are constantly calling our attention to this fact and asking us to do something if we can. That is a problem and a factor that I don't imagine you people are entirely acquainted with.

In closing let me say that I can assure you that the railroads are vitally interested in this thing, eager to work out any problems that you have with them and will go a long ways toward the correction of this thing if it is possible. I hope that we will have the cooperation and enjoy your neighborliness in the future and in behalf of the railroads we ask

your further cooperation. I thank you.

MR. FREED: Thank you Mr. Perkins. Comes now the time to call on the various State representatives for the State reports:

## CALIFORNIA STATE REPORT

Murray R. Pryor

Field Supervisor, Weed Control  
California Department of Agriculture

Mr Chairman, I wish to mention some of the weed control developments in California which I think will be of interest to this group.

To begin with, I would like to report the progress that has been made in the selective weed control program in grain. Barley, wheat, and oats are the three main grain crops in California. Barley is the foremost cereal crop in the State. In 1947, 1,964,000 acres were planted for all uses and 1,545,000 acres harvested for grain. Wheat ranked second with 825,000 acres planted for all purposes and 729,000 acres harvested for grain. Oats was represented in 542,000 acres planted for all purposes and 180,000 acres harvested for grain. It is estimated that about one-tenth of the total harvested acreage, or approximately 250,000 acres, was selectively treated with 2,4-D.

Most of the grain field pests are annual weeds and appear very early in the growing season, thus establishing themselves as winter annuals. Yellow star thistle (*Centaurea solstitialis*), mustard (*Brassica sp*) and wild radish (*Raphanus sativus*) are notable examples. From the standpoint of acreage wild morning glory is by far the most objectionable perennial weed. Russian knapweed (*Centaurea repens L.*) and hoary cress (*Cardaria draba*) have become fairly widespread perennials but the total infested acreage is comparatively small.

Generally speaking, the results of using 2,4-D for grain weed control throughout the State have been very satisfactory, crop yields being increased 50% or more in many cases. There was some dissatisfaction with 2,4-D which I think can be ascribed to several factors, such as using sub-lethal dosage rates of 2,4-D acid; treating when atmospheric conditions are unfavorable, and spraying too late.

Another program that certainly deserves mention is selective weed control in rice. It is estimated that approximately 100,000 acres of rice in California were sprayed with 2,4-D in 1947. This represents a very great increase when compared with the 8,000 acres sprayed in 1946.

The most prevalent waterweed, exclusive of the grass family, are arrowhead lily (*Sagittaria sp.*), water plantain (*Alisma sp.*), redstem (*Ammannia coccinea*), bulrush (*Scirpus sp.*), sedge (*Cyperus sp.*), and cattail (*Typha sp.*). Two rice weed pests not heretofore generally known came to the attention of the growers

this season, namely, water hyssop (*Bacopa rotundifolia*) and rough-seed bulrush (*Scirpus mucronatus*). Water hyssop has long been established in water courses throughout the San Joaquin Valley and further south but never had been a crop pest. Its importance was recognized as a rice weed pest when rice fields in the Firebaugh district in Fresno County showed heavy infestation. Water hyssop has also been found in rice in the Sacramento Valley. The second pest, rough-seed bulrush, had been observed in Butte and Glenn counties rice fields for the past few years by rice growers, but its potentiality as a serious pest was not fully recognized until 1947.

Arrowhead lily, water plantain, cattail and sedge are probably the most common weeds found in California rice fields at this time. Of these, cattail seems to be the most difficult to control with 2,4-D and results have been anything but satisfactory; sedges are difficult to control but respond more readily than cattail; generally, arrowhead lily and water plantain have been easily controlled where properly treated. From preliminary observations, rough-seed bulrush may be classed as a plant rather easily killed when treated with the proper dosage rate. The other newcomer, water hyssop, unfortunately has not responded satisfactorily to 2,4-D.

Generally speaking, the results of the 1947 selective spray program in rice have been satisfactory, although a considerable number of the Sacramento Valley Growers were very much dissatisfied as a result of using sub-lethal dosage rates of 2,4-D for weed control in their fields. In many instances, 2,4-D was sold and bought on the basis of price rather than upon the rate of plant susceptibility. Several other factors contributed to the unsatisfactory results. As in the case of the sub-lethal acid rates, extremely low application rates of spray solution failed to give good results. Limited field observations indicate that rates of 3 to 5 gallons of solution per acre are not sufficient to give a degree of coverage that will result in good control. In addition there was the matter of spraying too early or before the weeds in the rice fields had sufficiently emerged.

The pre-emergence spray program for control of weeds in sugar beets is in its incipient stage. The research people of the College of Agriculture at Davis have been conducting some very interesting experiments along this line. This work appears promising and, no doubt, will have far reaching effects, resulting in more economy in the growing of sugar beets.

Various phenolic weed killers were used in these experiments which included dinitro secondary butyl phenol and pentachlorophenol. Sulphur was tried in conjunction with oil; straight diesel oil also was applied.

Preliminary test work revealed that: (1) The elim-

ination of weeds through pre-emergence spraying produced a more vigorous crop plant; (2) cultivation of treated areas was not necessary until well after thinning; (3) it cost less to block and thin sprayed areas than unsprayed areas.

In view of these findings it appears that pre-emergence weed control in sugar beets will become a very important farm practice.

The use of oil in vineyard weed control is a new practice particularly well suited to vineyards that are heavily infested with a perennial weed like Johnson Grass. Ordinary cultural practices have not been effective in the control of this pest, and as a matter of fact have contributed to its spread. An advantage of using oil is that the Johnson grass plant remains in place and the roots are not moved by cultivating implements. With the systematic application of oil for a period of three or four years the Johnson grass is eradicated. In partially infested vineyards a combination oil and cultural practice may be carried on. It has been reported by a member of our bureau that the Wilson Ranch in Tulare County has been using oil weed control in its vineyards for the past three or four years and found it so effective that it has become a permanent practice. Where the oil method is used exclusive of cultivation, the amount of oil per acre decreases successively with each year until a minimum is reached.

Weed control with electricity has been in the developmental stage for the past few years and not until 1947 was it possible to evaluate this method. During the past year it was demonstrated that such perennial weeds as Russian Knapweed and Morning-glory can be effectively killed by electricity. The information gained comes from several years of field operations and without the benefit of scientific study that could have been made at the Experiment Station located at Davis. Field operators have learned that to control weeds satisfactorily with electricity the soil in which they grow must be fairly moist. Dry land infestations are pre-irrigated before they are treated. With present equipment five to seven treatments of such perennials as Russian Knapweed and Wild morning glory are required for satisfactory control. Initial treatment of alkali mallow appears promising and, no doubt, as time allows the susceptible list of perennial weeds will be extended. It is felt that the electrical killing of weeds will find a place in the general weed control program where other methods are not suitable. It will be necessary, however, to have further scientific information about this method.

Many other weed practices are becoming well-established in California such as the selective use of dinitros in seedling alfalfa; the use of dinitros in oil for weed control in dormant alfalfa; the use of selective dinitros for flax, peas, and onions; and the selective use of oil for weed control in carrots. We are looking forward to new developments

in 1948 to bring aid to the farmer in his fight against weeds.

## IDAHO STATE REPORT

V. A. Cox  
Superintendent  
Ada County Weed Council

Weed control in Idaho during 1947 was advanced to a greater degree than any of the previous years. This has been due in part to the activities of the Idaho Noxious Weed Association and the splendid work of Eugene Whitman, State Extension Agronomist, as well as the efforts of our research men C. I. Seely and Lambert C. Erickson of the University of Idaho and Jess Hodgson, Bureau of Plant Industry located in Ada County at Meridian.

The State Association climaxed its efforts in the most successful meeting it has ever held at Moscow Aug. 7-8-9. There was the largest attendance we have had so far. Well over 100 people were in attendance. The keynote of this meeting was the stressing of Public relationship in weed control through our County Commissioners, County Weed Supervisors and County Agents to the landowner's of the various Counties.

The first day's meeting was highlighted by a tour in the Grangeville area in the trial plots for selective spraying with various 2,4-D's for control of Crowfoot in wheat fields, carried on by Seely and Erickson. This work showed great promise as to results, not only in control of Crowfoot but also increased yields per acre.

Seely and Erickson are indeed to be complimented for this splendid effort in the control and eradication of Crowfoot which will undoubtedly prove of great value to wheat growers in selective spraying. The next two days were spent in Moscow in discussion and viewing plot work on the campus and also at Genesee in field work on field bindweed and Canada thistle, carried on by Seely and Erickson. In plot work at the University on various crops a tour was led by K. H. Klages, Head of the University of Idaho, Department of Agronomy. His talks were very interesting and informative. Plot work on control of lawn weeds on the campus was ably conducted, Lambert C. Erickson showing varied results by use of the different amount of 2,4-D.

The plot work at Genessee was carried on by C. I. Seely with field bindweed. This project was to determine the best methods of clean cultivation on dry land areas as well as effects of selective spraying of cereals at different periods of growth. A great amount of work has been carried on in this area by Seely. Great interest was shown by those in attendance and valuable information obtained.

The discussions carried on in this meeting were three fold, and of a round table nature.

### 1. PROBLEMS OF A COUNTY WEED SUPERVISOR

Round table discussion by county weed supervisors of the Budget, and problems pertaining to their Counties. Results obtained and future plans for the coming year's work.

### 2. WEED PROBLEMS OF A COUNTY AGENT

This was a round table discussion by County Agents regarding problems arising in the various Counties. Particular stress was made on how much responsibility should a County Agent assume in weed control where there is no weed Supervisor. It was decided that this was a matter of education, working with farmers, teaching him how to control weeds.

### 3. PROBLEMS OF COUNTY COMMISSIONERS IN WEED CONTROL

Round Table Discussion by County Commissioners. Subjects: 1. Public Relationship, 2. Loss on money by weeds, 3. Actual findings and expenses.

It was decided that more stress should be placed on Public Relationship; that people are becoming more aware of loss through weed infestation; that there should be continued clarification of weed laws. It was emphasized by the Commissioners that there was a need for a State Supervisor of Noxious Weeds in the State Department of Agriculture, on a basis comparable with the heads of the various departments already in existence.

Resolutions were passed asking for additional research on poisonous range weeds, such as Halogeton, goat weed and lupine and other important weeds, particularly blue flowering lettuce on dry farms and weed control in pastures. The State University was asked to stress weed identification and weed control in their Curriculum. It was asked that short courses in different sections of the State be established for the training and information to County Commissioners, County weed supervisors and county agents. This request has been granted by the University and schools will be held in four different sections of the State during the month of February immediately following this Conference. These schools should advance greatly the knowledge and efficient methods of weed control and eradication. They are being conducted by Research men and Agricultural Engineers under the direction of Eugene Whitman, Extension Agronomist. We believed this to be one of the greatest advancements made by the Idaho Noxious Weed Association. It might be of interest to members of this Conference to have some knowledge of the creation and purposes of the Idaho Noxious Weed Association.

This Association was formed and created under the direction of the State Association of County Clerks and County Commissioners of Idaho in February 1944. The usual compliment of officers elected to fill their respective offices and a Board of Directors of five members. Each Director is the Chairman of his group of Counties which are designated as his territory. He is empowered to call meetings as necessary, in his district, for discussion with the county

commissioners, county weed supervisor and county agents in problems arising from the weeds in his district. In addition each Director makes reports to the State Association on the progress in weed control in his respective area. He is also a member of the Board consisting of the President, Secretary-Treasurer and the other directors, subject to the call of the President for Special Meetings relative to problems arising from a state-wide angle. This has been found to be a very effective organization. Funds are allotted to the Association by the parent organization from their treasurer, for carrying on of business such as legislative efforts for changes in Law relative to Weed Control, travel and expenses for officers of the Association to and from meeting places wherever they may be. All officers serve without pay other than necessary expense of travel, lodging and meals. The purpose of this organization was to encourage more uniform methods of weed control in the respective districts which are fairly uniform as to geographic and climatical conditions.

It has been found very worthwhile for educational purposes, for reports of State, Federal and Industry, for sponsoring weed legislation, research men in soliciting help from various agencies and in promoting research and extension work in weed control. That it has paid in a remarkable manner is evidenced by attendance of Idaho weed men at the Western Weed Conferences during the last four years.

Number of counties having weed supervisors	24
Number of counties having county extension agents	39
Number of counties having weed budgets	34
Total amount of weed budgets	\$680,136.37

### CULTIVATION PROGRAM 1947

Number of farms beginning cultivation for weed control, 1947	401
Number of acres beginning cultivation for weed control, 1947	4021.35
Total number of farms under cultivation	1043
Total number of acres under cultivation	37753.11
Total number of acres released from cultivation	1375.56
Total number of pounds actual 2,4-D acid used	146,334.00
Total gallons of CS <sub>2</sub> supplied to farmers	24,663.00
Total pounds of Sodium supplied to farmers	1,373.072

The above figures were taken from Extract of a State Report for County Agents and Weed Supervisors for 1947, submitted to Eugene Whitman, Extension Agronomist.



## WEED CONTROL INVESTIGATION OF IRRIGATED LANDS OF IDAHO

J. M. Hodgson, Assistant Agronomist  
Division of Cereal Crops and Diseases  
Bureau of Plant Industry, Soils and  
Agricultural Engineering, USDA

A weed experiment station was established on irrigated land in southern Idaho financed out of a special appropriation authorized by Congress in 1946. This station is under joint supervision of the U. S. Department of Agriculture, the Bureau of Reclamation and the Idaho Agricultural Experiment Station. Field operations began early in 1947. The first year was occupied largely in starting the experiment station but a few research projects were begun and some worthwhile information obtained. A summary of that work is reported herewith. The observations are in many cases preliminary and final evaluation will not be possible until next season.

One of the more important experiments was a comparison between the weed-killing power of the "Electrovator" and 2,4-D. The "Electrovator" is an electric weed-killing machine that has recently received much publicity. Observations made in October revealed that white top plants treated four times with the "Electrovator" showed as much as 70 per cent regrowth. By contrast, plants that received 4 pounds of 2,4-D showed only about 15 per cent regrowth. The plants receiving 4 pounds of 2,4-D and 5 days later followed by one treatment with the electrovator had about 30 per cent regrowth. It should be pointed out, however, that on both areas that received 2,4-D there was an abundance of roots, apparently still alive, 8 inches below the surface. The final outcome will not be known until next year.

Observations also were made of several weed infestations that were treated with electrovator by county authorities. Bindweed, Canada thistle and whitetop infestations generally were not reduced by three electric treatments. Some were slightly reduced after five and six treatments, others were not noticeably diminished. The excessive cost of repeated electrovator treatments and the poor results generally achieved indicate that electrovator is not a practical means of weed control in this area. The general effect of the electrovator in this area was negative.

A preliminary test of contact herbicides as a means of cleaning ditchbanks of troublesome growth was made late in 1947. Four materials were used: Shell Weed Killer No. 20, Atlacide, Dow General, and Diesel oil. Applications of  $\frac{1}{2}$  gallon of Shell 20 per square rod resulted in almost complete top kill of timothy, orchard grass, cattail, and sedge. Atlacide at  $\frac{1}{2}$  pound in 1 gallon of water per square rod resulted in about 85 per cent top kill. Diesel oil

at 1 gallon per square rod and an emulsion of 30 per cent diesel oil and 70 per cent water fortified with 0.4 per cent Dow General did not give a satisfactory top kill. However the failure of the mixture containing Dow General could have been due to faulty application.

Some interesting tests of herbicides were made on aquatic weeds. Various species of submerged vegetation infest irrigation canals in this area and retard the flow of water. Two trials with the proprietary substance Benoclor both gave satisfactory control of sago pondweed (*Potamogeton pectinatus*) and restored the canals to capacity for a period of several weeks. The Benoclor was sprayed under water at such a rate as to produce approximately 200 ppm concentration and was held in contact with the plants for 1 hour. Although the treatment was expensive, the increased delivery resulting in these canal systems was considered worthwhile because of the urgent need for the water.

A test with copper sulfate applied to sago pondweed resulted in unsatisfactory control. The flow of water in the canal was increased temporarily but injury to the weed was very limited and recovery soon nullified the benefits of treatment. A considerable quantity of white precipitate formed as the copper sulfate was added to the water indicating some loss of the copper as an insoluble precipitate. This probably is one reason for the unsatisfactory results.

Recent findings by the Bureau of Reclamation Laboratory in Denver of a solvent coal tar naphtha toxic to some aquatic weeds is a very promising opening. The material is very economical to use. A test of this material was conducted October 2, 1947, and although conditions were unfavorable for best results and the irrigation season was practically over, some valuable information was obtained. Solvent naphtha with an emulsifier added was applied into the canal in sufficient quantity to produce approximately 200 ppm concentration in the water. The naphtha was held in contact with the weeds for 1 hour. Five days later about two-thirds of the foliage of infesting plants had died and disappeared. It is believed that better results would have been obtained if the treatment had been made earlier at a more favorable stage of growth. Further tests of this material will be made early next season.

### COLORADO STATE REPORT

Bruce J. Thornton  
In Charge Weed Control Investigations  
Colorado A & M

The provisions under which the Colorado weed control program is conducted were outlined in last year's report and need be reviewed but briefly here.

The work is carried at the county level, provisions

being made for an entire county or any part of a county being designated as a weed district by the county commissioners. The weed control effort is then carried on on a cooperative voluntary basis. Some counties provide equipment for treating weeds on private lands and others limit their operations to county highways and county lands, leaving the work on private lands to be handled by custom sprayers or by the individuals. On this basis more weed districts are constantly being formed and the program is advancing by its own momentum probably as rapidly as is advisable.

Provision is also made for setting up compulsory weed districts but at present no such districts have been formed and probably will not be until such time as the voluntary districts fail to accomplish the desired results.

### RESEARCH RESULTS

A sufficient number of years have elapsed since making the first treatments with 2,4-D to permit making observations on a somewhat sounder basis than was possible heretofore and as time goes on the information gained will be more and more dependable.

Field bindweed treated in September in 1945 in a test involving seven 2,4-D compounds, at three rates of application, replicated three times, showed an average regrowth of 6% the following year accompanied by a marked increase in grain yield as compared to the untreated area. The regrowth of bindweed the second year averaged 30% which caused but little, if any, depression in the yield. However, it is quite probable that by the third year the bindweed will be sufficiently heavy to again seriously reduce yields illustrating the point that in general the control of perennial noxious weeds requires constant attention and the development of a definite program designed to correlate the control efforts with other farm operations. In these tests there was no significant difference between any of the chemicals used, or between the rates of application, which were unnecessarily high in these first tests.

Three years treatment of Russian knapweed and Canada thistle has resulted in excellent control in pasture and roadside tests. In the roadside tests the heavy stand of mixed grasses which came in as a result of reducing the weedy growth may have aided in the control. This condition did not obtain in the pasture tests since the grass was rather closely grazed. Again in these tests the differences between chemicals and between rates were not strongly significant, although in the case of the knapweed the amine salt ranked first with the sodium salt second and the two esters (ethy and butyl) on a par, definitely in third place.

Treating bindweed in spring wheat late in the season when the wheat was headed had no effect on that crop but resulted in an increase in yield in

winter wheat the following year of approximately 100% over untreated areas, with no significant differences between chemicals, (sodium salts, amine salts, esters), between 1 pound and 2 pound rates actual 2,4-D per acre, or between amounts of water used in making application.

The treatment of silver leaf poverty weed (*Franseria discolor*) in spring barley was delayed by wet weather until the boot stage. It was realized that this was a critical period from the standpoint of possible injury to the barley but it was felt this would favor comparison of the effects of different types of 2,4-D and to this end and because control of poverty weed was a prime consideration the treatments were made at the rate of 1 and 1½ pounds actual 2,4-D per acre, application being made by tractor equipment at 50 gallons per acre. In the one pound treatments the sodium salt showed a definite increase in yield, the amine salt no appreciable difference, with the isopropyl and butyl esters showing definite reductions in yield, the latter approaching 40%. In the 1½ pound applications the sodium salt showed no difference in yield over the check, with the amine salt, and isopropyl ester giving some reduction and the butyl ester a reduction approaching 60%. Statistical analysis to determine significance has not been completed and the degree to which the poverty weed was affected cannot be determined until next year.

In treating spring barley, free from perennial, biennial and winter annual weeds, the yield was reduced in all instances, including the treatments with Sinox and removal of weeds by hoeing, the reduction being greatest with the butyl esters and lowest with the sodium and amine salts of 2,4-D, with no appreciable difference between the last two. Reductions in yield from application made in June were on the average about double those made in May.

Similar treatments in winter wheat, free from perennials, biennial and winter annuals, also showed a slight reduction in all treatments and with no appreciable difference between chemicals. The hoed plots yielded slightly less than the checks. Dates of treatment gave greatest difference in results; the June treatments showing an average reduction of 14% as compared to 2% for the May treatments.

The above tests on spring and winter grain, not infested with serious weeds, appear to indicate the fallacy of treating grain fields of this type with the idea of increasing yield through removal of normal weed competition. The plots in these tests were located in this particular grain field because of the presence of a rather heavy spring infestation of common weeds and for a time it looked as though they might furnish some strong competition. At harvest time they were, of course, entirely eliminated from the treated plots, but were present only as spindling plants in the check plots, indicating that

they had not exerted much influence on the development of the crop. There will be instances where the use of 2,4-D in controlling annual as well as more serious weeds in the cereals will be highly desirable and profitable, but undoubtedly, through perverted publicity and high pressure salesmanship many acres of cereals similar to those involved in the above tests will be unnecessarily treated with 2,4-D compounds at an actual loss to the growers.

It has been recommended that susceptible crops such as alfalfa, clover, beans, peas, cantaloupe, cucumber, tomatoes, etc. should not be planted for a period of from 30 to 60 days following the application of 2,4-D. The results we obtained in Colorado from preliminary field tests involving these and other crops and observations of field operations indicate the need for further investigations of this phase of the study of 2,4-D application. Closely associated with this is the need for more information as to how soon it may be possible to plow up or otherwise disturb weeds treated with 2,4-D without decreasing the effect of the treatment.

The main weed problem in Colorado is that of controlling and preventing the further spread of the noxious perennial weeds and we are more concerned at the present time with solving this problem than with the possibilities of the chemical control of those common weeds that heretofore have been controlled successfully by good farming methods, except, of course in those special situations where the need for or the advantage of chemical control is without question. Many of the reports of remarkable savings from treating annual weeds in corn by the application of 2,4-D appear to be an indictment of the farming methods leading to such situations although emergency situations, such as occurred in Kentucky and other sections of the corn belt this past spring, arise from conditions beyond the control of the operators and call for special treatment. In general it appears that the economic practicability of the substitution of the application of 2,4-D compounds for cultivation in the control of weeds in corn and similar crops will be definitely limited in some sections at least because of the ineffectiveness of this material against grass type weeds and some of the resistant broad-leaved weeds. However, amazing developments in all phases of weed control may be expected in the future.

## WASHINGTON STATE REPORT

W. C. McMinimee  
Weed Division Supervisor

Mr. Chairman, Gentlemen: In the State of Washington we have a survey map of the State by counties; we have all of the noxious weeds--we hope all of them anyway--on this map. We brought a few with us if any of you are interested in having them. I will

be over there in the corner and will be glad to give you one. Some of our chemical men up there have been with us on this survey and I think it has helped us to know just where they are. I am not going to bore you with the statistics--just give you a few of the highlights.

I. Weed control in the State of Washington is divided into four major problems.

1. Economic loss to the farmers and lands in the state.

2. Weeds as a harbor of plant disease.

3. Weeds as a harbor of insects.

4. Weeds constitute a public health problem.

II. The action program phase consists of control and eradication of weeds on irrigated and non-irrigated farm lands with special attention to aquatic, ditch banks and water sheds, public utilities and public lands.

Major emphasis has been placed on control of noxious weeds with increased interest and action on annual weeds (pre-emergence, contact, selective spraying) which is and will be an important factor along with good farming practices.

The State Weed Division under the State Department of Agriculture is coordinating the State action program and is assisting counties, farm groups and commissioners in forming county weed districts and weed extermination areas. Farm organizations of the State have active weed committees and their ideas and suggestions have been the basic plans for state weed program.

Washington State College this past year has added to their staff Dr. Lowell Rasmussen. Mr. Victor Bruns from the Bureau of Plant Industry, USDA, has recently been added to their staff and is stationed at the Prosser, Washington, Experiment Station. These men have started research and experimentation programs in the State and we expect to receive much needed information this coming year.

Weed research men should be added to the Puyallup, Washington, Experiment Station to perform research and experiments for the coastal areas to determine the best methods of control and eradication of noxious and annual weeds.

In discussing the weed program, several factors of interest and importance have been observed. It has been necessary to collect many facts or data before recommendations on weed control could be made.

### III. EVIDENCE

Importance of evidence and different kinds of evidence; that weeds are complex organic compounds with the result that it is more difficult to determine always the elements of cause and effect of different herbicides and other methods in weed control.

### IV. ENVIRONMENT

Environment has had great influence on weeds.

## V. EXPERIMENTS

Many experiments or observations have been repeated (such as cultivation) and found successful; however, on different types of soil, cultivation in hilly terrain has not been practical because of soil erosion. The State of Washington weed control herbicide program this year has gone through a year of experimental projects by many chemical companies, farmers and farm groups. More than 5 times more herbicides were used this year than last year with 2,4-D esters leading in its group three to one.

## VI. AGREEMENTS IN WEED CONTROL

In some farm areas there is the:

1. *Method of Agreement* among farmers where soil textures, etc. are similar and farmers through farm organizations have had the opportunity to discuss the best methods of control of weed problems;

2. *The Method of Difference* or where soils or similar circumstances are common except one spraying or cultivation may have been done during an unusual period such as rain or fertilization. This difference has often caused new results which have been a discovery.

3. *The Joint Method of Agreement* in weed control. However, in most areas where soil and climatic conditions are similar, certain methods of weed control have been developed with such evidence obtained by observation or experiment by farmers and others which will serve as a guide for the 1948 weed control program.

## VII. DISCOVERIES AND SURPRISES

The systematic research plus an action weed program is very important. The element of surprises and accidental discoveries has been an important factor also this year. In the State of Washington weed program there has been the disagreements between Experiment Stations and research workers on proper uses of herbicides and their continued research has led to dependable facts. Ideas from farmers have been an important source of discovery. Farmers have discussed weed control within their respective organizations. Weed Committee groups are active in their State farm organizations and through their farm newspapers weed items of interest have been published.

## VIII. THE PERSONAL FACTOR

Individual research men differ greatly in the way they attack certain problems and so it has been with the farmers in attacking their weed problem. There has been the element of systematic and chance errors, in mixing materials and in operation of machinery.

Users of herbicides on the farms have drawn conclusions from too few data on certain weeds; while others have had a tendency to generalize from data on experiments and have not taken into consideration soil, moisture, climatic conditions and general good farm practices. More technical information should be published in bulletin form to assist farmers on

proper use of herbicides on each noxious weed.

## IX. FARM MACHINERY

Soils in the State of Washington vary in moisture, drainage, texture, depth and available plant food from lawn to acreage, farm to farm and county to county. Weed individuality in many cases differ with different crops which brings the point of adaptation of proper machinery (contact, pre-emergence, low or high pressure, electrovibration, burning) to the farm and its attack on noxious weeds.

To coordinate all the above mentioned factors on large pea and wheat farms, the small diversified irrigated farm with different soils, climatic and drainage, the many methods of control and proper machinery, with the personal factor, has been a few of the problems that we have over come this 1947 year and from our past findings, along with research data, the State of Washington will develop its 1948 weed action program.

## RECOMMEND FOLLOWING PROCEDURE AND TOOLS NEEDED FOR STATE OF WASHINGTON WEED PROGRAM Federal

1. That additional funds be given the Bureau of Plant Industry, Soils and Agricultural Engineering of the Department of Agriculture to carry out the needs of the program, and that additional experimental work be carried on by the government in irrigated sections of the West on control of important noxious weeds and that the work be closely coordinated with the work of the State Department of Agriculture and State Experiment Station.

State

1. A careful and logical analysis of the weed problem in all areas of the State.

2. The State Department of Agriculture through a State Weed Control Supervisor who will be delegated to coordinate all agencies within the State into a strong action weed program.

3. State-county-farmer matching of funds for payments of county weed supervision and eradication of noxious weeds before infestation starts.

4. A rigorous and exact research and experimental program of experiments with data on equipment, methods and cost which will assist the personal factor.

5. Publishing of research and experimental data in bulletin form.

6. That labels of 2,4-D weed killers give the information as recommended by the Central Weed Control Conference, 1946-1947.

County

1. A well organized county action weed program coordinated by a county weed supervisor.

2. A county weed advisory committee selected by farm organizations who will act as a steering committee and advisory committee to county officials.

## STATE WEED CONTROL SURVEY 1947

Number of farms reporting in the State. . . . .	79,737
Number of farms reporting noxious weeds . . . . .	50,256
Farm lands reporting noxious weeds (acres). . . . .	1,255,198
Non farm land (acres) noxious weeds . . . . .	1,711,387
Farm acres non-productive because of noxious weeds . . . . .	120,736
Amount paid to farmers by A.C.A. (Agri- cultural Conservation Association) for weed control (approximate). . . . .	\$158,282

Summary of Weed Control Practices in the State of Washington as reported by:

	<u>County Agencies</u>	<u>A.C.A.</u>
<u>Cultivation</u>		
Farms .....	8,869	
Acres .....	497,112	8,772
 <u>Mowing and Burning</u>		
Acres .....	8,000	
 <u>CHEMICALS</u>		
 <u>2,4-D</u>		
Farms .....	5,186	
Acres .....	271,630	2,108
Pounds, 2,4-D .....	60,169	179,094
2,4-D liquid, Gals. ....	7,388	687
 <u>Sodium Chlorate</u>		
Pounds .....	1,981,149	1,419,447
Gallons .....	14,000	
 <u>Altacide</u>		
Pounds .....	15,700	
 <u>Carbon bisulphide</u>		
Pounds .....	250	14,997
Gallons .....	2,155	
 <u>Ammate</u>		
Pounds .....	3,060	
 <u>Borax</u>		
Pounds .....	1,400	15,400

	<u>County</u> <u>Agencies</u>	<u>A.C.A.</u>
<u>Borascu</u>		
Pounds.....	4,000	500
<u>Electrovation</u>		
Acres .....	300	
<u>Triox</u>		
Gallons .....		70
<u>Shell 20</u>		
Gallons.....		560
<u>Thinner</u>		
Gallons .....		13,952
<u>Diesel</u>		
Gallons .....		2,627
<u>Iron Sulphate</u>		
Pounds .....		1,721

Money spent by county for Weed Control:

<u>General Fund</u>	<u>District Fund</u>	<u>Total</u>
\$133,159.00	\$ 12,760.00	\$146,119.00

#### WEEDS SUSCEPTIBLE TO 2,4-D

These weeds have been effectively controlled by the use of 2,4-D:

Arrowhead lily	Poison Oak
Austrian fieldcress	Prostrate pigweed
Beggar ticks	Prickley Lettuce
Black medic	Puncture vine
Blue lettuce	Purslane
Bull thistle	Red clover
Burdock	Rough pigweed
Bur-reed*	Russian thistle (young)
Buttercup	Sedge
Canada fleabane	Sheep sorrel**
Canada thistle**	Smartweed
Cattail*	Shepherd's purse
Cheese-weed	Sow thistle (annual)
Chickweed	Sow thistle (perennial)**
Chicory	Spiny clotbur
Cocklebur	Spotted spurge
Creek nettle	Star thistles
Curly dock	(rosette)
Dandelion	Sweet clover
Dog fennel	Teasel
Fan weed	Tules*

Hoary cress*	Tumbling pigweed
Indian strawberry	Water hemlock*
Kelp*	Water hyacinth
Klamath weed (St. Johnswort) *#	Water plantain
Knotweed	Water primrose
Lambsquarters	Western ragweed
Milk thistle	White horse nettle
Mouse-ear chickweed	Wild buckwheat
Mustards	Wild carrot
Nettle	Wild lettuce
Pennywort	Wild morning-glory**
Perennial dogbane*	Wild radish
Perennial ragweed*	Wild sunflower
Plantain	Willows*
Poison hemlock	Yellow star thistle

#### WEEDS RESISTANT TO 2,4-D

These weeds are difficult to control by the use of 2,4-D:

Alkali mallow	Mayweed
Annual bluegrass	Milkweed
Baby tears	Mullein
Bermuda grass	Nutgrass
Blackberry	Oxalis
Bluegrass	Quackgrass
Bracken fern	Ripgut grass
Buttonwillow	Russian knapweed
Crabgrass	Sandbur
Foxtail	Soft chess
Goldenrod	Tansy ragwort
Goosegrass	Watergrass
Horsetail	Wild barley
Italian ryegrass	Wild oats
Johnson grass	Yarrow

These weeds have been divided into two main groups as a matter of convenience, but such a division is tentative, and the lists may change as more tests are conducted and more information becomes available. Weed response to 2,4-D depends upon various factors. Esters of the 2,4-D acid are more effective on HARD-TO-KILL-WEEDS.

#Borax: 4 to 6 pounds or 1 pound of Sodium chlorate plus 3 pounds Borax per square rod or more, provided enough rain falls during same season to leach it into the zone of absorbing roots.

\*\*Sodium Chlorate: 3 to 4 pounds per square rod or more provided enough rain falls during same season to leach it into the zone of absorbing roots.

\*Those marked by an asterisk(s) (\*)(\*\*) may require two or more treatments.

## OREGON STATE REPORT

Rex Warren

Extension Specialist in Farm Crops  
Oregon State College

Weed research like other types of research is of little value unless it has practical application. For this reason Oregon's report is to be of a dual nature. First, a brief outline of the research work under the leadership of our President, Mr. Virgil Freed, and secondary, the educational weed program in charge of Extension Specialist in Farm Crops.

Our friend Virgil really plans to kill all the weeds in Oregon, or know why, during 1948 due to the help of his newly appointed assistant, Mr. H. E. Behrman.

Work during 1947 has included many phases of weed work. There has been continued investigation on the soil fumigants for the control of perennial noxious weeds. The effectiveness of these materials have proven themselves for the control of white-top, morning-glory, Canada thistle, Russian knapweed and quackgrass. One of the major problems to be worked on during 1948 will be improved methods of applications of these soil fumigants. We feel in Oregon that these materials are going to play an important part in our eradication program.

Work has been continued on the use of the di-nitro sprays and new contact herbicides have been under investigation.

### 2,4-D

The use of 2,4-D materials has occupied a lot of space in the research program. We are continuing to investigate methods of application, rates of application, volume and type of carrier agents. These materials have been used both selectively and for the control of perennial weeds.

In addition to the use of 2,4-D formulations, we have investigated various other growth regulator chemicals.

The physiological and bio chemical actions of growth regulator chemicals are being studied in the weed laboratory. It has been found that growth regulator materials have certain effects on the enzyme systems of plants. Plans are to continue this study during the coming year.

### Educational Meetings

The Oregon Extension Service through the Extension Agriculture Engineer and the Extension Farm Crops Department held a series of weed equipment meetings through 25 Oregon counties. These meetings were arranged in conjunction with equipment manufacturers and weed chemical companies representatives. As many as ten different pieces of dust and spray equipment were shown at each meeting. At the time of the meetings there was a discussion on the uses of equipment by Extension Agricultural Engineers and the equipment was shown in operation. Each representative of the

equipment was given an opportunity to discuss the merits of this equipment with interested farmers.

After the equipment discussion there was a report on weed control by a representative of the Farm Crops Department. These 25 meetings throughout all of eastern Oregon and the Willamette Valley proved especially popular, there being an attendance of approximately 3200, which is an average of 128 farmers per meeting. This is an excellent showing, considering that several of Oregon's counties have less than 500 farmers.

The chemical company representatives attended the tours; made displays of their respective chemicals and had an opportunity to discuss with each farmer chemical weed control.

Arrangements have been completed for a series of five additional meetings covering Oregon Coast Counties. After this tour is completed all but five Oregon counties will have been contacted with these meetings; while two of these counties attended joint meetings with a neighboring county.

The Farm Crops Extension Department publishes periodically a small leaflet entitled, "Weeders Readers". This was originally planned to keep Oregon County Agents advised on new weed developments. It has proven so popular that 400 copies are being mimeographed and mailed to interested individuals and organizations. This leaflet is published four or five times a year.

## MONTANA STATE REPORT

H. L. Dusenberry  
Extension Weed Specialist

Perennial weeds have continued to increase the number of acres infested in the state. Most of the counties have a very real interest in the problem and weed districts are being created as fast as the people are ready for them. The state now has 23 counties which have districts organized under the state law. In four other counties, a voluntary program is being carried out, usually in cooperation with the Agricultural Conservation Program. The counties who do not have a program at present are interested and are working toward creation of a legal weed control district. Those who have only a part of the county in districts are generally interested in enlargement to eventually include the entire county.

Up to last year, chlorate and clean cultivation were the principal methods of control for perennial weeds in Montana. 12,500 acres were under clean cultivation on a supervised basis last year. County weed districts applied 471,911 pounds of chlorate and 33,567 pounds of borax for perennial weed control. In addition to this, 2,4-D was used to treat 7,194 acres of perennial weeds. The tendency has been during the past two years to use 2,4-D in place of, or



## NEVADA STATE REPORT

Lee Burge

State Department of Agriculture

in combination with, cultivation as a weed control practice for perennial weeds. Canada thistle and bindweed will be treated rather extensively with 2,4-D in the state during the current season. Whitetop will probably also receive treatment with 2,4-D in many counties.

The theory is developing in the state that 2,4-D can be used on the more susceptible perennials, either in combination with cultivation or as a selective spray in growing crops on a year to year basis with fairly good results. In other words, through continuous treatment a gradual reduction in stand is expected with the possibility of an eventual eradication. The fact that 2,4-D is a rather low cost treatment accounts for much of this interest.

Probably the greatest interest in weed control during the past season was that with respect to annual weeds. County Agents reported that 43,607 acres were treated in growing crops. This is a very conservative figure since much of the work was done by individuals and custom sprayers. An estimate of the total figures would probably be at least 2 or 3 times greater than the one reported by the County Agents.

The prospect is that in the coming year probably 30 to 50 per cent of the grain crops in Montana will be sprayed. It is interesting to note the accelerated interest in custom spraying which has developed. Quite a number of companies have been organized to do custom spraying on farms and to service the needs of farmers with respect to annual weed control.

Equipment has also become more available and many farmers will purchase their own equipment and spray their crops. Last year probably the majority of the treatment was performed by using dust. A very decided shift toward liquid sprays is now in evidence. Both cost and the effect of wind have largely been responsible for this shift. Low gallonage sprayers have accounted for making the spray more practical in the state also.

With regard to recommendations in the state, the amount of 2,4-D has been greatly reduced during the past year. Rates of 1/4 pound and up will be probably the most common. At the present time, the principal use of 2,4-D for annual weeds will be in connection with small grain crops, used as a post-emergence selective spray. With regard to gallonage, most of the counties are recommending from 10 to 20 gallons. From the state standpoint we feel that slightly lower gallonage with a range of 5 to 15 gallons per acre will give satisfactory results. No recommendations have been made thus far on pre-emergence sprays since we feel that more testing should be done to determine the timing and effect on various crops.

For the first time since the enactment of the Nevada weed law we can report a wide and sincere interest in weeds and their control by all individuals and agencies directly associated with agriculture.

The present knowledge of the new weed-killing agents may be the spark long since necessary to arouse Nevada agriculture from its self sufficient stupor under which have been buried good judgment and the first principles of sound farming practices.

Sound farming practices must be employed if we are going to maintain land values and produce crops at a cost low enough to insure a fair and equitable profit for the producer. Let us ask ourselves, "Where would the nation's production be today had the noxious weed problem been handled properly during the past fifteen years?"

We estimate that Nevada's forty-odd thousand acres of weed-infested lands are responsible for a million dollar loss annually. This is not considering the heavy loss each year from poisonous plants, added labor cost, harboring and breeding of insect pests, and loss in general quality of products produced. An estimated ten per cent of Nevada's irrigated agricultural land is out of production due to weeds.

Many things have been learned in Nevada since the first weed control program was instituted in 1929. At that time research information was meager, and mostly unreliable, making the first control efforts necessarily largely experimental. This led to many costly mistakes along with many good results. Caution, perhaps to the extreme, has resulted.

We know now, after three years of careful trials, that many of the newer herbicides have a place in the economic weed control picture. On large acreages cultivation, flooding, and competitive crops have not, and probably will not, be replaced by chemicals as sound control practices.

To strengthen our situation we are proposing to our agricultural people that the Nevada law be so amended as to permit the creation of weed control areas when requested by taxpayers in the particular political subdivision involved. Either part, or the whole, of a given county would be considered as the control area. New infestations would be kept out by proper control of animals fed infested feed grown within the areas, and by restricting the movement of infested feeds into the control area.

To aid the counties a state control fund would be set up to be used only in declared areas with the state contributing funds equal to those set up by the local control district.

New developments with 2,4-D indicate that camel thorn and leafy spurge, previously entered on the

susceptible list should be removed. In turn, iris and bassia can be removed from the resistant to the susceptible list.

The most promising use of 2,4-D has been in the heavily weed-infested grain areas. Acreages formally abandoned on account of bassia, morning-glory, white top and knapweed have this year produced a clean grain crop when treated with 2,4-D. These acreages were sprayed at rates varying from 1 pound to 3 pounds of acid per acre and at gallonages varying from 12 to 100 per acre. With all of these weeds, and particularly white top, pre-irrigation or irrigation shortly after spraying has given generally better results. It is advisable to point out here that contrary to certain reports we have seen no evidence of a 100 per cent permanent kill on the perennials white top and knapweed sprayed in grain. These plants have been kept from seeding and have shown a complete top burn for sufficient time to allow a good and clean crop of grain, with some permanent kill. Our recommendation will be a second year of grains sprayed at 1½-2 pounds per acre followed by a third year of either a row crop, pasture, or alfalfa, depending on the per cent of plants remaining. Generally speaking, results on knapweed with 2,4-D are not yet satisfactory, although the average kill has been near 50-60 per cent after two applications with certain isolated cases of 95 per cent kill. White top has, by and large, been found more susceptible.

The most troublesome of our grain weeds, bassia, has been sprayed at all stages of growth and at all maturities of the grain. This practice has been due to the fact that bassia did not all germinate early making it necessary to wait until, in many cases, the grain was in the ripe stage. Germination tests run on many fields of grain at 30-day intervals showed a progressively higher germination with each test. One field of wheat and one of barley showed a below normal germination on the third test. One sample of wheat germinated only one per cent on the original test but reached 99 per cent on the third. This field had been sprayed when the grain was practically matured. A field of barley sprayed at the same time also germinated one per cent followed 90 days later by 94 per cent. A field of oats sprayed early at a height of six inches with 1½ pounds of 2,4-D germinated 24 per cent followed in 90 days with 84 per cent.

The over-all average germination of grain sprayed with 2,4-D in the early growth stage was 94 per cent and of the grain sprayed in the dough and ripe stage was 92 per cent.

One plot of white top sprayed with 2,4-d in the late pod stage produced only 1/22 as many seeds as an adjoining unsprayed plot. Although the seed produced by the sprayed plot germinated equal to the unsprayed seed some favorable results are seen in the decreased production of seed.

It is becoming more evident that weeds in Nevada are playing host to many disease transmitted to agricultural crops by insects. One acreage of potatoes on virgin soil was virtually abandoned this year because of the heavy damage to potato tops by flea beetle, thrip, and lygus which were bred and carried over on bassia, dock, plantain, sunflower, white top, and Russian thistle.

Likewise our alfalfa seed producing areas and field-grown transplants are in danger of serious damage by insects unless an intensive weed program is expanded and continued. It is not enough that these insects be controlled after they migrate to our cultivated crops from nearby weed areas.

The Truckee Meadows Water Hemlock program has made some progress but has not had the support from farmers, and water company and agricultural officials originally expected. However with heavy cattle losses this fall we expect this program to pick up momentum. Based on a previous survey of the principle canals in the valley we find that approximately 190 miles of canals plus many more miles of feeder ditches are infested. The program, as outlined, calls for use of 2,4-D at an annual expenditure of \$4500 under the supervision of the county Weed Supervisor. It is expected that the program will extend over several years, and it is hoped that adjoining California counties can also be interested, along with the Forest Service and wild game officials.

Halogeton has continued to spread with the most westerly infestation at Calvada and the southern points of Hawthorne and Tonopah.

Two intensive halogeton control programs have been developed; they are at Hazen in Churchill county and on the Naval Reservation at Hawthorne. These programs are based on use of hand grubbing and soraying with dinitro and oil. The Navy has been very cooperative and we hope for some permanent results.

Pre-emergence spraying of row crops and alfalfa in meeting with increasing interest. This program has proven particularly satisfactory in onions and in the field grown plant districts.

Many Nevada farmers are now taking advantage of the P M A program for weed control which in 1948 allows payment for chemical and cultural control of Canada thistle, white top, knapweed, morning-glory, water hemlock, yerba mansa, burdock, narrow-leaf milkweed, larkspur, iris, blue lettuce, quack grass, Johnson and Bermuda grasses.

To qualify for payments for control of quack grass, Bermuda, and Johnson grasses, cooperators must use only cultivation methods.

Rates of Payment Allowed by P M A.

(a) Chemicals(except oil and 2,4-D)----50% of cost not to exceed \$10.00 per acre.

Sample Number	Kind	Treatment	Germination		
			1st Test	2nd Test	3rd Test
3129	Winter Wheat (E)*	Sprayed 24D May '47, 3 1/2# to A	18%	84%	98%
3130	Barley (E)	Sprayed 24D June '47 Exp. plot 3/4-1# A	9%	33.5%	97%
3131	Wheat (E)	Treated 24D May, 1 gal ester to 500 gal. water Grain 5"-8" high	48%	94.5%	99%
3132	Wheat (E)	Treated 24D May, 1 gal Ester to 700 gal. water. Grain 5"-8" high	17.5%	99.5%	99.5%
3133	Wheat	Not treated	53%	87%	89.5%
3134	Wheat (L)*	Sprayed late	7%	92.5%	94.5%
3135	Wheat (E)	July 1 sprayed in boot	50.5%	92.5%	90%
3136	Oats (E)	Sprayed early, 3"-8" high	24%	86%	84%
3137	Barley (L)	Late spray, 1 1/2 pts.	1%	45.5%	94%
3138	Wheat (L)	Wheat ripe, sprayed 1 1/2 pts. Bassia at 18" when sprayed. Knockdown good.	1%	90.5%	99%
3153	Wheat (L)	Sprayed late 24D	62%	73.5%	72%
3154	Wheat (E)	Sprayed 24D in boot in May	92%	93%	95.5%
3164	Trebi Barley (L)	24D in dough	91.5%	94%	95%
3165	Marklan Oats (E)	24D in leaf	92%	88%	91.5%
3166	Bannock Oats (E)	24D in leaf	95%	87%	93%
3167	Federation Wheat (L)	24D in head	95.5%	96%	99%
3168	Federation Wheat (L)	24D in head	97%	97%	97.5%
3174	Wheat (L)	24D in head	86%	90.5%	89%
3122-3126	Wheat	Sprayed 24D in 1946	72%	90.5%	93%
3117-3121	Barley	Sprayed 24D in 1946	54.5%	71.5%	72%
Average for seed from fields sprayed early			49.5%	84.2%	94.2%
Average for seed from fields sprayed late			55.1%	84.9%	92.4%

\*E -- sprayed early

L -- sprayed late

- (b) Clean cultivation over season for all weeds designated except quack grass, Johnson and Bermuda grasses --- \$7.50 per acre.
- (c) For cleaning and cultivation of quack grass, Johnson and Bermuda grasses throughout the season --- \$5.00 per acre.
- (d) 2,4-D --- 50% of cost but not to exceed \$1.75 per pound of 2,4-D acid used.

At long last weed control has finally been recognized by agricultural workers as an essential operation, which can, and will, with a sane and cautious approach by agricultural officials and manufacturers of herbicides, pay dividends to our Nevada agriculture.

### WYOMING STATE REPORT

George B. Harston  
State Entomologist

The weed control work in Wyoming during the past year has taken a wholesome trend toward the shift of responsibility from county and state government control to landowner control. It is estimated that at least fifty per cent of the control work by spraying has been done or hired by the landowners. Many farmers and ranchers are purchasing their own equipment and applying their own chemicals. They are learning that legislative appropriations have not been adequate to support a program of control equal to the spread of the weeds. They have also learned that the use of a small hand sprayer sometimes can control a tract of weeds in less time than it would take to report the infestation to the county crews and wait for them to get to the job of spraying.

County weed control crews have worked on approximately one thousand farms in 1947, in applying 2,4-D sprays. These crews sprayed approximately 7,000 tracts covering about 700,000 square rods. Weeds receiving most attention in this spraying program were Russian Knapweed, Field Bindweed, White Top, Canada Thistle, Ragweed, Willows and Dandelions. Varied results were obtained.

Borax and Borascu were applied on about 32 farms. One ranch purchased a carload of borascu and applied it themselves. The tracts treated by county crews covered approximately 4600 square rods. Those using borax and borascu reported good results when adequate moisture was present to dissolve the chemical and carry it to the roots. Unfavorable results have been obtained when this moisture condition did not exist.

Atlacide remains popular with some farmers and ranchers. About one hundred farmers applied

atlacide on 2367 tracts covering 3180 square rods. Favorable results were obtained.

Clean cultivation by county crews is a practice which is being rapidly replaced by spraying. Only 45 farms were worked, covering approximately 140 acres.

Permanent pasture seeding and smother cropping is increasing as a means of weed control in some counties. This program is combined with a spraying program.

Four counties are now circulating petitions for the formation of legal pest control districts. These counties have not previously had these districts. One encouraging feature of this move is that these counties are composed largely of livestock men, who are recognizing that organized effort is important in the control of weeds which are effecting their range and meadowland.

Those of us who have been working on the weed control program in Wyoming for several years recognize much improvement in the attitude of farmers and ranchers; and, we feel that the State Experiment Station has made a definite step forward toward our progress by selecting a full time weed research man. Mr. Dale Bohmont, who is with us at this Conference, will devote his full time to weed research in Wyoming. We are confident that his services will aid our control program greatly.

### UTAH STATE REPORT

George L. Hobson  
State Supervisor

This report will be given as briefly as possible in an effort to bring out the major items with respect to our 1947 weed eradication program, and it will deal with the use of 2,4-D, chlorates, and cultivation.

#### 2,4-D

2,4-D has been used in Utah for the past two years on quite an extensive basis. It was approved by the state weed eradication committee on the basis of a control chemical and on the basis recommended by the western weed eradication conference, which convened in Portland in 1947. Through lack of information with respect to its use, we have depended largely upon the recommendations of the manufacturer. Many of its uses have born out the useful qualities it possesses as recommended by the manufacturer. Yet, we have found some things to be quite to the contrary. Having used it two years has not revealed too many important things from the standpoint of eradication, but as a control chemical it has served our purposes far in excess of other chemicals. The extensive use to which 2,4-D has been applied in Utah is attributed to the fact that it can be dispensed by equipment much more rapidly and much more easily, and at less cost than other kinds of chemical. I am quite sure

that we can say of 2,4-D it would be an extremely difficult thing to discourage farmers from using it, even in view of the erratic results.

Most every trade brand of 2,4-D has been used. The use of various brands was much more extensive in 1947 than in 1946. From information as revealed from experiment and the western weed eradication conference, we advised our various counties that the ester type was the most dependable, and I am not yet convinced but what this is the case. However, the difference in the various kinds of chemical has not shown wide enough results to lay much stress on the esters as against salt base. In the reports received from our county supervisors we tried to ascertain the brand of chemical that gives best results. Fully two-thirds of them preferred to use one of the ester brands, and when asked the question which gave best results, there was not enough preference shown to justify recommending any brand of chemical for the coming season. Weeds which responded most effectively to 2,4-D were annual plants, and among the perennials, morning glory and whitetop responded quite satisfactorily, especially is this true with reference to seed development. Results were very irregular when applied to Russian knapweed or Canada thistle.

Very few counties treated infestation in growing crops. Where these lands were treated in cereal crops, the results so far as control were very satisfactory.

2,4-D was used extensively on canals, mountain streams, fence lines and pasture lands.

At the outset of the 1947 season, we recommended a light solution of about one-tenth of one per cent for wild morning glory and almost double that amount for whitetop, Canada thistle and Russian knapweed. Canada thistle responded quite universally. Most of the fruiting was stopped and tops killed. However, there was a large portion of crown regrowth. In the case of Knapweed the fruiting process was stopped but the plants remained green and quite a percentage began to show crown growth in the fall. Many of our supervisors claim that the latter three mentioned will require a much stronger application than on wild morning-glory. With more difficult weeds, the control results appeared to be much better where there was strong competition, such as a heavy grass pasture land, or grassy banks or roadsides, or in any crop that was heavy enough to offer strong competition.

An estimate of the 1948 requirements was ascertained from the county, and in all cases an increased demand was noted. This is a strong point which justifies us in the statement that farmers are more satisfied with the use of 2,4-D than other kinds of chemical. Results of control with the major weeds in crop land revealed a fair percentage of eradication ranging from 20 to 95 per cent. The percentage of eradication was much greater, however, in

lands with strong competition. We tried to ascertain from its use in the counties what changes could be made to improve its effectiveness. Invariably, there was no particular general information that would change the procedure from the procedure now followed. Where failures had resulted, we tried to ascertain the cause. Many valuable answers were given, such as the lack of moisture, the lack of sufficient foliage, uneven emergence, etc.

In attempting to find out the stage of growth when 2,4-D should be applied, the opinion, both from the angle of control and the angle of eradication, was when plants were fully matured with plenty of foliage and approaching, or in the early stages of fruiting.

In the early use of 2,4-D, especially in 1946, we used quite a number of hand sprays. As power sprays became more prevalent, we discovered that the application was more effective; therefore, we used every effort possible to have equipment equipped with boom sprays, and at the close of the season they were almost universally used. There are many private spray machines in operation. These privately operated machines have been very cooperative and have followed our recommendations quite satisfactorily. We have done all we could to encourage the private equipment, and we will continue to do so in an effort to speed up weed eradication control in Utah. We have found that there is a great possibility for farmer-owned equipment, especially if it is priced within their reach and can be equipment they use on the farm.

Some spraying was done following the removal of crops, and many of the areas gave very promising results. There was quite a divided opinion, however, as to the length of time that should elapse between the removal of the crop and the spraying. Our experience has not been extensive enough to make many determinations. I am quite sure, however, that this after-harvest spraying will occupy a very important place in weed eradication.

#### USE OF CHLORATES

The use of chlorates is diminishing very rapidly. Several of the counties who had carryover supplies on hand have dispensed them. They used it mainly on Quackgrass, Burdock, Poison Whorled Milkweed, etc.

Although the use of chlorates is diminishing, there is no question but what it still has a place in weed eradication, especially on areas where sterilization is not important and on plants which do not respond to 2,4-D. We are only using about one-tenth as much as in previous years.

#### CULTIVATION

Like the use of chlorates, the cultural method of eradication is also diminishing. Yet, several of our counties still cultivate a sizeable acreage. In some of our counties the cultural method is increasing slightly, but in most counties the trend is downward. Nearly every county has ample equipment. All counties with the exception of two own equipment for

dispensing chemical and for cultivation.

As in the use of chlorates, we are sure that cultivation methods have a lasting place in weed eradication, and we expect to encourage its use in all counties where results justify.

#### QUARANTINE

In 1947 we closed an area placed under blanket quarantine. Every farmer in this area was visited in the early establishment of the quarantine, and every farmer had a weed eradication program on his farm. He devised his own method of eradication where county equipment was not available. This brought into existence many privately owned operators. The quarantine area was very satisfactory and proved the speeding up of weed eradication and control in that area. Every person not only became weed conscious but became interested to the extent that we thought it advisable to release the quarantine, and the same good results were followed up by the farmers after the release of the quarantine.

In another area of the state, a blanket quarantine was placed in 1947 and will continue to operate largely under the same plan as the first one. The terms of quarantine will be to stop infested grains, hay, straw, etc. from going out of the quarantine area, unless released by the district agriculture inspector, and to control livestock from spreading this infestation to uninfested areas.

Where blanket quarantines are applied, each land owner is visited, given a personal quarantine and a weed program worked out. If county equipment will not be available, other laws are devised to help the farmer. We also quarantine many individuals outside of areas covered by a blanket quarantine.

#### PROGRAM

At a recent meeting of the State Weed Eradication Committee, known as the Correlation Committee, a revision of the weed eradication program was proposed, bringing it up to date, and it is now in the process of reconstruction. As soon as this conference is over, the results of the same will be embodied.

Chairman Freed introduced Dr. C. J. Willard, President of the North Central Weed Control Conference who presented the report of that Conference.

Following Dr. Willard, Dr. K. S. Quisenberry of Washington, D. C. reported on the National Weed Program.

Dr. Ernest Walker was not present to read his paper but it is included in these proceedings. The following are the above-mentioned reports and papers:

## REPORT OF THE NORTH CENTRAL WEED CONTROL CONFERENCE

C. J. Willard

Associate in Agronomy  
Ohio Experiment Station

It has been my very unusual pleasure and privilege these last three days to visit this pioneer Weed Control Conference as a delegate of the North Central Conference. It is my first visit--I hope it may not be the last. I have enjoyed your splendid sessions. I bring you the greetings of the North Central group, which followed your excellent example four years ago.

Weed control is growing up. This does not mean that it is mature by any means. There are three classes of farm pests--weeds, insects and diseases. All estimates of losses from weeds exceed those from injurious insects or plant diseases. Yet we have probably over 2000 professional entomologists and perhaps 1000 professional plant pathologists in the United States. I hesitate to make a similar guess at the number of full-time weed control specialists there are in the United States but I feel fairly sure it is less than 200, and most of those are with private industry. Too many of us in the Experiment Stations give only a small fraction of our time to weed control research. But ten years ago you could have counted on the fingers of your hands the men giving full-time to research on weed control.

Now we are growing up with all the growing pains suffered by any awkward youngster who is all arms, legs and uncertain voice. We will not reach maturity until we know the life history of all important weeds under many soil and climatic conditions, their susceptibility to all relevant chemical herbicides at various stages of maturity, and their possibility of control by cultivation, mowing, crop competition, insects, etc. By that distant future, we should also have expanded our extension, educational, regulatory and control activities to the point where we at least do not ship viable weed seeds in hay, feed and seed all over the country to be resown on clean areas or areas on which the same weeds have just been cleaned up at great expense.

Testimony to our rapid adolescence is offered by the tremendous interest and attendance so far at this conference; by the attendance of over 600 at the Topeka meeting of our four-year old conference; by the newly organized Northeastern Weed Control Conference, holding its second meeting in New York next week; by the hundreds of articles in farm papers on weed control, instead of the previous tens; and by the feverish activity of dozens of companies selling weed control materials and equipment.

The unfortunate feature of this activity is that its research base is now much too small. Everywhere in the United States we need immensely more research.

Perforce, industry is now required to do a considerable share of the current research. This is good, but public research should match it, for the good of all concerned.

This requires that all of us help to educate administrators, legislatures, boards of trustees, and all other governing and appropriating bodies to the vital importance of weed control research to economical food production and the protection of valuable land from partial or complete occupation by weeds.

We need more personnel for research. We in Ohio have been hampered in weed control more in 1947 by lack of personnel than lack of money. Weed control is a new profession--one of the best available to the young man starting in the agricultural field. Here again is a job of education for all of us--to encourage competent young men to take up this new profession, one which will grow with almost explosive speed as we try to catch up with our older colleagues in the control of agricultural pests.

At the North Central meeting, most of our first day's meeting and the first part of the second--a solid day, all told--was given over to reports of progress from those who had been conducting research, reporting their results for the year. These results were reported also in a booklet of 172 mimeographed pages, representing the largest single weed control publication for several years.

Several of our older agronomic colleagues have been very critical of us for putting out, as they say, "half-baked" data in this way. We felt, and feel, that such reporting is justified and important. We research people are paid by the taxpayers of the states and the nation to solve problems of importance to them. However little we know at the end of a season, we at least know far more than one who has not worked with the problem at all. We feel that the man who is interested is entitled to know all the information and suggestions that we can offer. We feel that he is entitled to them now, when he wants it--not three years hence, when the information will be more accurate, of course, but it will be information which he will already have obtained from experience or other sources. He may misuse or be misled by the information--surely--but that is true of any information and any suggestions that may be offered, however sound they may be.

Active discussion followed each presentation, and they were among the most favorably received features of the meeting.

Our Policy Committee on Herbicides, consisting of the Research Committee plus a number of persons concerned with weed law enforcement, met the afternoon and evening before the conference started and drafted a tentative report. This was mimeographed and distributed to the group for discussion the morning of the second day. For an hour and a half this report received intensive general discussion and criticism. Several recommendations in the final report were

changed as a result of these discussions.

The corrected report was outlined at the last session of the Conference and was mimeographed and mailed a week later to every registrant at the Conference.

We have also been criticized for making these recommendations. We know they won't all be satisfactory, but as with the research reports, we feel a responsibility to offer the best we have. If we felt that something simply could not be recommended this year we said so.

It would be superfluous as well as impossible for me to make any attempt to summarize any of these reports. You have had and will have similar locally adapted reports.

Inevitably, most of the research in the North Central region has been empirical. We have had so few people to answer so many questions that we have been compelled to neglect that fundamental research on which our ultimate progress depends. This has been necessary for the present, but we look forward to the time when we can give the same careful, precise study to the life history, physiology, ecology, and eradication of each weed that the entomologist does to each new insect which threatens us.

One important source of funds for weed control research should be the Research and Marketing Act of 1946. Some such funds are already being used, as Dr. Quisenberry will tell you shortly. For any additional work, this Act must be implemented with additional funds by Congress. If this is done, a significant part of the next funds available is almost certain to go to weed control.

Weed control activities in the North Central region in 1947 were extremely varied. In the Northwest, treatment of weeds in spring grain was especially important. In many areas, the amount of spraying done was limited only by the available equipment. In the main corn belt, there was considerable formal and informal experimenting with 2,4-D in corn. In many areas, corn which had been buried in horseweeds, sunflowers, cockleburrs and such during wet weather was rescued by more or less improvised treatment with 2,4-D. This has created so much excitement that almost every corn grower in the region is 2,4-D conscious. This may mean losses in several directions in 1948.

The North Central Conference organized a section on control of weeds in horticultural crops this year. It was a valuable session, for a group that would hardly have found it worthwhile to attend had this section not been formed.

Incidentally, the Northeastern Conference found it necessary to go to sectional meetings at its organization meeting last year, so great was the diversity of interests of those present, and their meeting this year plans four sections at one time. Weed control has grown far beyond the possibility or desirability

of everyone listening to reports on all its varied features.

Another sectional meeting at the North Central Weed Control Conference was on control of woody plants—a vital problem in many sections with us, as with you here. The information is even more scattered and unsatisfactory than that on herbaceous weeds, but more information on woody plant control was brought together in Dr. Melander's summary than has been given in one place before. As another part of that program, a valuable discussion of the control of weeds in nurseries was held.

The Weed Control Conferences, which were so auspiciously started by this group ten years ago, have developed into major Plant Science organizations. Transcending departmental lines, they are helping to break down some of the silly thought-tight compartments with which we University people so often surround ourselves. They have become a major factor in coordinating research, reporting results, and spreading information on the control of noxious plants of all kinds.

They must now work together to develop nationally a knowledge and appreciation of this new applied science, and to make nation-wide that exchange of information which has been so important regionally.

## WEED CONTROL RESEARCH IN THE BUREAU OF PLANT INDUSTRY, SOILS AND AGRICULTURAL ENGINEERING

K. S. Quisenberry

Interest in methods of controlling weeds has been increasing by leaps and bounds during the last decade. Meetings such as this are proof of this interest because since 1938 when 13 were in attendance this conference has grown until this year 401 have registered. At the North Central Weed Control Conference, held in Topeka, Kansas, in December 1947, over 600 people were present, and that was only the fourth annual meeting. The Northeastern Weed Control Conference is to assemble in New York City on February 12 and 13 for its second meeting. Last year at its first meeting this new conference had an attendance of 75 and this year several hundred workers are expected to be present.

This keen and widespread interest in weed control is pleasing to research workers, but it must have a sobering effect as well. Farmers are clamoring for answers to their problems. They have been sold on the results of Agricultural Research. This means that we have a special responsibility to see that they are not oversold or sold the wrong package. With the rapid advances in certain fields of weed control the application has gone far beyond research.

Research must catch up and go ahead.

Within the United States Department of Agriculture research work on the control of weeds is done by a

number of agencies, such as the Bureaus of Plant Industry, Soils and Agricultural Engineering, Entomology and Plant Quarantine, Animal Industry, the Forest Service, and the Soil Conservation Service. Each agency is interested in certain phases only and often to the exclusion of others. This means that care must be exercised to assure a balanced program and also that unnecessary duplication and overlapping be avoided. An attempt to do this is being made but weed research has expanded so rapidly this may not have been accomplished as completely as is desirable.

The present discussion will deal with the work in the Bureau of Plant Industry, Soils, and Agricultural Engineering. Weed research in this Bureau is conducted by the Divisions of Agricultural Engineering, Fruit and Vegetable Crops and Diseases, Forage Crops, and Diseases, and Cereal Crops and Diseases, all in cooperation with State Experiment Stations in the various areas. In this case the work is well coordinated so that each organization knows what is being done by others.

### EARLY HISTORY

The first experimental project in weed control research in the Department of Agriculture was started in 1902 in the Division of Agrostology of the Bureau of Plant Industry. This was an investigation of Johnson Grass in Texas. Some weed research has been underway since that beginning. During the period 1906-1915 important studies were made by the Office of Farm Management of the relation of weeds to intertillage and methods were developed for controlling quackgrass and wild onion. From 1915 to 1920 limited weed studies were handled by the Office of Forage Crops, and some progress was made with chemical weed-killers and with nutgrass control. In 1920 the work was transferred to the Office of Economic and Systematic Botany and in 1933 to the Division of Forage Crops and Diseases. From 1920 to 1935 no funds were available for Weed research, activities being limited to general observations and answering routine correspondence.

### WORK OF RECENT YEARS

The present research project was initiated in 1935 when a special appropriation was made by the Congress. It was organized as a project in the Division of Cereal Crops and Diseases so that overhead could be reduced as much as possible and a large part of the available money devoted to research. The first appropriation specified that work was to deal with the control of bindweed. Later the authorization was broadened to include white top and other noxious weeds, but since the program had been organized to work primarily on bindweed and funds were reduced rather than increased, it obviously was not possible to make significant advances with other weeds. In the cooperative bindweed research, however, some very significant progress has been made. It is no



exaggeration to say that as a result of this work bindweed is no longer feared as it once was. Banks and mortgage companies no longer refuse to make loans on bindweed infested land, and thousands of acres of once abandoned land have been restored to crop production. Cultural methods including cropping and intensive cultivation have been devised which make it possible for any farmer anywhere to keep bindweed under control and in some cases eradicates this pest with a fraction of the expense formerly thought necessary. Much basic information has been accumulated especially as regards root reserves, time, depth, and frequency of cultivation and crop competition. This has made it possible to devise effective, economical control methods for new areas and new situations with a minimum of field experiments. It has also provided many valuable leads for the control of other noxious weeds. In fact, the same principles have been found to apply to other perennial weeds so that here also effective methods of control can be devised with small expense for field trials.

It should be noted that this work did not start from scratch. In developing this program in cooperation with the various states, advantage was taken of much valuable experimental work conducted by State Agricultural Experiment Stations previous to 1935. That of the Kansas, Nebraska, Minnesota, Utah, California, and Idaho Stations especially should be mentioned. Root reserve studies with other plants especially alfalfa in indicating the role of reserves in regeneration and the maintenance of stands also played an important role in setting the pattern of this program.

The discovery of the herbicidal value of 2,4-dichlorophenoxyacetic acid and other chemicals inaugurated another phase of research. Unfortunately from some points of view this discovery coincided with the war and with reduction in funds and personnel, so that research progress has not been as rapid as might be desired. As a result, information now available is not always complete and in some cases is contradictory. Because of the great promise and in many cases spectacular results from this method of weed control, application has gone far ahead of research, usually with satisfactory results but in some cases resulting in failure or even serious damage to crops. Consequently there is still a great need for more work including fundamental studies to determine how and why these chemicals kill plants.

#### AQUATIC WEED WORK

In December 1945, the Department of Agriculture was asked to cooperate with the Office of the Chief of Engineers, War Department, on a study of the control of water hyacinth in the Gulf Coastal area. The project was financed by the War Department.

Water hyacinths have been a serious problem in rivers, reservoirs, and canals of the Gulf Coastal

area for years. This weed is a menace to navigation, clogs canals, and may seriously affect the supply of fish. Millions of dollars have been spent annually merely to keep open channels through the dense masses of these plants. Lack of funds forced the discontinuation of this project after a single year, but nevertheless it was found that 2,4-D applied at the proper rate and time will give complete control of this serious weed. 2,4-D is slow acting and dead hyacinth plants may remain afloat for 2 or 3 months. This mass of semi-decayed material is a serious obstruction to navigation. Some materials are now being tested which show promise in accelerating sinking of the plants. Effective combinations of chemical and mechanical control methods have been discovered which will open waterways to immediate navigation and minimize the amount of recovery from seedlings or escaped plants. There are some problems yet to be solved but there seems no reason to believe it will not play an important role in water hyacinth control in the immediate future.

#### SOUTHERN WEED WORK

One of the serious weeds of the Southeastern States is nutgrass which so far has not been brought under control. In 1946 the Congress voted a modest appropriation for a study of the control of this weed and as a result work is now underway in Mississippi and Georgia.

Although this project is very new, already some worthwhile results have been obtained. Nutgrass can be effectively controlled with soil fumigants, ethylene dibromide and chloropicrin being the most effective of this group of chemicals. It has been discovered that the key to successful control seems to be in breaking the apical dominance either by chemical or cultural methods and the forcing of all tubers into production of leafy shoots.

#### WEED WORK IN THE WEST

In 1946 funds were appropriated by the Congress for the study of the control of weeds on ditch banks, in irrigation canals and reservoirs, and on irrigated lands of the West. This appropriation was obtained at the request of and with support from the Bureau of Reclamation of the Department of the Interior.

This project has now been in operation during one growing season and naturally any findings are preliminary. A physiologist is located at the Denver Laboratory of the Bureau of Reclamation cooperating in the study of aquatic weeds. The Bureau of Reclamation transfers funds to the Bureau of Plant Industry, Soils, and Agricultural Engineering to pay this man. Field men are located at Phoenix, Arizona; Prosser, Washington; and Boise, Idaho. Each cooperates closely with the Bureau of Reclamation and with the respective State Agricultural Experiment Stations. The Bureau of Reclamation, through

both regional offices and irrigation districts, provides extensive facilities and assistance. In each case the men work on weeds that are most serious in the area.

An additional man has been designated as coordinator for work in the irrigated area. He is to be headquartered at some station in the western area to coordinate all cooperative weed research and to tie the program in with work being done by state or other Federal agencies.

Within the limits of available funds a good start has been made on several serious weed problems. A few items indicating progress may be noted.

Tests with the "Electrovator" on white top and bindweed disclosed that top growth is readily killed but root systems are not seriously affected even after repeated applications. Mr. Hodgson conducted these tests at Meridian, Idaho, in cooperation with the Ada County weed control supervisor.

In a joint discovery by personnel of our Bureau and the Bureau of Reclamation at the Denver Chemical Laboratory of the latter Bureau, it was found that the carrier used in one of the proprietary 2,4-D compounds was toxic to aquatic weeds. When the carrier was analyzed the toxic constituent proved to be a coal-tar naphtha. Later a cheaper petroleum naphtha was found to be just as effective as coal-tar naphtha and much less expensive than present chemical control methods. Mr. John Shaw of the Bureau of Reclamation has given (or will give) you an account of these tests.

In tests conducted by Mr. Bruns at Prosser, Washington, certain of the aromatic oils satisfactorily controlled cattails and other emergent aquatics which infest water delivery systems. These same oils were found to be effective as general weed killers on ditch banks and other non-cropped land in Arizona. Johnson grass was controlled by one-half the usual number of applications when the aromatic oils were used.

These contributions to the general knowledge of weed control practices in irrigated areas made within the short period of one year are most encouraging.

#### NEW WORK

With the passage of the Research and Marketing Act of 1946, new funds were made available for weed research work. A project entitled: "To establish a cooperative national research program to develop practical methods and equipment for weed control," has been approved and some funds allotted for its support. As the title indicates, it is proposed to develop a national cooperative, coordinated weed research program, although the amount of available funds will not permit doing this on an entirely adequate scale. Some of the money has been allotted to work on weed control equipment. Only a part of the funds requested were allotted the first year. Later it is hoped support can be increased. A more modest start, how-

ever, is not entirely undesirable since the scarcity of trained men would have made it difficult to use efficiently much more money than was available.

With the money now available plans are going ahead for a somewhat broadened weed research program. First of all, it has been possible to obtain an assistant for the leader of the weed project in Beltsville, Maryland. With the tremendous interest in weed control correspondence has become a serious burden, and with enlargement of the program, this was a much needed move. A physiologist has been employed to work with Dr. Mitchell at Beltsville to study the physiological effects of 2,4-D and related chemicals as a base for control practices. Work is to be started on the control of weeds on the range lands of the Texas and Oklahoma area, and consideration is being given to work on weeds in sugar beet fields of Michigan, Minnesota, and North Dakota. An ecologist will be located at Lincoln, Nebraska to study crop-weed competition in that area.

Considering coverage of the country as a whole, the western set-up has been sketched. In the central part of the country cooperative work is underway in North Dakota, South Dakota, Minnesota, Nebraska, Iowa, and Kansas, with work being planned for sections of Texas and Oklahoma. A coordinator will function in this area.

Further east the program is not yet definitely developed although some work is being carried on. As mentioned before, work is being started in Michigan on weeds troublesome in sugar beets. At Beltsville, Maryland, certain laboratory and greenhouse studies are in operation, and plans have been made for chemical studies on known herbicides and the synthesizing of new ones. Some of the work now underway at Beltsville illustrates the type of basic research which seems to be one of the Bureau's primary functions. A scientist cooperating with the hormone project is using radioactive isotopes in an attempt to trace through the physiological mechanisms involved in the toxic action of herbicides on plants. In other studies of a highly technical nature an attempt is being made to determine whether a relationship exists between the molecular configuration of chemical compounds and their phytotoxicity. In time there will need to be a coordinator for this northeastern area and an initiation of cooperative work in the more humid areas.

In the Southeastern States nearly all of our work has been limited to nutgrass control with men located in Georgia and Mississippi. Limited studies are being made on the pre-emergence control of weeds in soybeans. This shows how a worker is often forced to initiate work in closely related fields. The area is in need of more work, especially with other serious weeds.

#### STATE-FEDERAL COOPERATION

For more than fifty years the Division of Cereal

Crops and Diseases has operated on the basis of cooperative effort, believing that the most progress can be made in that way. This is also the accepted policy of the Bureau. Most problems are extremely broad and must be attacked from many angles if the proper solution is found. Whether a State, Federal or commercial agency helps to do the work is not important in the end, so long as the job is done. Most progress can be made by all working together, yet there will always be plenty of credit for the individual worker, as long as credit is given where credit is due.

All of the weed research of the Division has been and is cooperative with State Experiment Stations, other Divisions of the Bureau, and with other Bureaus. This policy has been followed in the improvement projects with various cereal crops and from results obtained there can be little question of the soundness of the idea. At present the Division has two-thirds of its employees located at 42 different places in the United States.

Basic research is a primary function of our weed control project. It is not "Ivory Tower" research, however, but is such as is expected to provide a better understanding of principles and thereby lead to more effective, economical and practical methods of control. Usually such basic research is carried on at the same laboratory or experimental field as the so-called practical research and by the same personnel. This means that any discoveries relating to principles are immediately put to practical use and likewise any practical problems that require more basic information are immediately given attention. For example, knowledge of why 2,4-D kills some plants under certain conditions and not under others, would be of great assistance in devising better methods of using 2,4-D or point the way to more effective herbicides. The demand for practical answers to immediate problems has sometimes led to over-emphasis of problems that are not the most important. We hope to avoid this in developing a long-time program. The question may be asked as to how the cooperative programs operate. First of all, it must be emphasized that organization and operation are absolutely voluntary on the part of all concerned. Due to limitations of funds most state scientists must work within the boundaries of their respective states. They are, therefore, in a position best to attack problems of immediate concern to their own states, yet their findings may be applicable in other areas. Federal appropriations are usually not so restricted and for this reason Federal men may work on problems of a broader geographic coverage and are likewise obligated to do fundamental work which may have a wide application. By investigation a Federal man may often function effectively as coordinator in helping to synthesize Federal and state work in an area. This is not done in any way to dominate the

picture, but rather to serve in bringing work and workers together and through suggestions to make the total work more effective. As a service the coordinator may assemble annual data accumulated by cooperators, summarize these data, and make them available to all concerned in the program. Such a clearing house for information may advance progress very materially.

#### WEED PROJECT OR DIVISION

At present the principal weed work in the Bureau of Plant Industry, Soils and Agricultural Engineering is organized as a project in the Division of Cereal Crops and Diseases. This was done originally, as previously noted, because of the limited amount of funds available for the work. Questions have been raised as to restricting work to bindweed or to nutgrass. The reason for this latter has been noted in that first funds were clearly earmarked by Congress and the Division had no original choice in the matter. It takes time to clear up these first projects. Various organizations and individuals from time to time have shown interest in having more weed work, and have requested the Bureau to expand their program. The Bureau has recognized the desirability of such increase, and has made a strong effort to get the needed support, but various circumstances of public policy, including the effects of the war, have made progress slow. During and immediately before the war there was an actual decrease in funds. Present prospects are more favorable, but efforts for further support must be continued and emphasized.

I know that many of you feel that there should be a separate weed division and that your organization has urged the establishment of a Weed Research Division in the Bureau. Other organizations have done the same. The Bureau is in favor of an autonomous weed division just as soon as it is clear that the job can be more effectively handled by such an organization. If present plans materialize for the fiscal year 1949, a Weed Research Division probably will be established within the year. The weed problem cuts across all crops and affects all sections of the country. From this point of view alone a separate Division would be desirable. It should be remembered, however, that a Division must carry considerable overhead, which is costly, and so long as the weed work is a project within a Division a much higher proportion of the money goes into research than would be the case if a separate Division were organized. The work gets the same attention in the Bureau whether it is a project or a Division.

There is every reason to believe that weed research will be considerably expanded in the near future. A number of the states have received additional funds for weed research. In the North Central Region progress is being made on an over-all project involving work in 13 states with plans for participation by

the Bureau of Plant Industry, Soils, and Agricultural Engineering.

The efforts of this group and of other area groups, including your own, are certain to promote an intensified interest and enlargement of program throughout the country. All of this should result in better financial support. You can rest assured that the Bureau of Plant Industry, Soils, and Agricultural Engineering will do all that it can to advance its program so as to carry its share in the obligation.

Recognizing the primary importance of the weed problem, and the certainty that interest and activity in weed research is sure to increase, the Bureau of Plant Industry, Soils, and Agricultural Engineering plans to set up a National Weed Advisory Committee to obtain the best help possible in developing its program. As we see it now such an advisory committee should be representative of the farmer, state and Federal research workers, and it may be also industrial organizations servicing weed control operations through sale of weed machinery and chemicals. As plans develop your organization will be requested to make suggestions.

In closing, I wish to emphasize that the Bureau of Plant Industry, Soils, and Agricultural Engineering is keenly conscious of its responsibilities and obligations to give the American farmer the best possible service in meeting his weed problem. We need your help and want you to work with us to that end.

## EXPLANATION OF THE PRINCIPAL FEATURES OF THE FEDERAL INSECTICIDE, FUNGICIDE AND RODENTICIDE ACT

Dr. E. A. Walker

Chief, Fungicide and Herbicide Section  
Insecticide Division, Livestock Branch  
USDA, Production and Marketing Administration

Your Secretary, Mr. Ball, informs me that your organization is much interested in the Federal Insecticide, Fungicide, and Rodenticide Act, which became a law on June 25 of last year and replaced the Insecticide Act of 1910. This new act greatly extends the coverage relative to the sale and marketing of economic poisons, since it now applies to rodenticides, herbicides and devices intended for pest control, in addition to insecticides and fungicides which were covered by the Insecticide Act of 1910.

Devices covered by the law do not include equipment, such as sprayers and dusters, used for application of economic poisons when sold separately from them or equipment, such as hoes, rakes, weeders or electrovators, used to destroy weeds. If the equipment is sold with the economic poisons -- as, for example a herbicide in a lawn or garden duster or, looking to the future, an aerosol dispenser represented to contain a herbicide -- the whole is subject to the act.

A device so sold is misbranded if its labeling bears any statement, design, or graphic representation relative thereto which is false or misleading in any particular.

According to the act the term "herbicide" means any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any weed. The term "weed" means any plant which grows where not wanted. A "weed" would include annual and perennial broadleaf plants, moss, ferns, sedge, grass, shrubs, trees and aquatics or "emergent" plants.

According to the law, a product is an economic poison if it is intended to be used as an insecticide, fungicide, rodenticide, or herbicide. The definition is substantially the same as the definition in the Insecticide Act of 1910 for insecticides and fungicides and is interpreted as covering substances for such use, either as packed or after dilution with some substance or substances. Examples are fly spray concentrates intended to be mixed with kerosene, or esters, amine, sodium or ammonium salts of 2,4-dichlorophenoxyacetic acid to be mixed with water for use as a herbicide. Products which are intended for economic poison use only after a manufacturing process, such as grinding to dust form, or compounding with other constituents, which cannot readily be carried out without special equipment, are not considered to be economic poisons. For example, crude cube root, which must be powdered or extracted before use, is not regarded as an insecticide; but cube powder, which is used directly or after mixing with talc or water, is so regarded.

A single substance may have several uses, some of them for economic poison purposes. For example, sulfur may be used to make sulfuric acid. This acid when diluted may be used as a herbicide to kill weeds in a field of carrots. Sulfur may also be used to vulcanize rubber, or as a fungicide on plants. 2,4-dichlorophenoxyacetic acid may be used as a herbicide or it may be used to prevent fruit drop in apple orchards. Stoddard Solvent may be used as a weed killer or it may be a cleaning fluid. A substance of this character is not considered to be an economic poison as long as it is sold only in general channels of trade for that substance and there is no intent that it will be used for economic poison purposes.

One of the most significant features of the new act is the provision which requires all economic poisons to be registered with the U. S. Department of Agriculture before they can be marketed in the District of Columbia, Territories, or moved in interstate commerce. This applies, as well, to all economic poisons imported into the United States. It is not required that devices be registered.

The law provides that an applicant, to obtain registration of an economic poison, such as a herbicide, must file with the Department of Agriculture

a statement including:

1. The name and address of the registrant and the name and address of the person whose name will appear on the label, if other than the registrant.

2. The name of the economic poison, or herbicide.

3. A complete copy of the labeling accompanying the herbicide and a statement of all claims to be made for it, including directions for use and such caution statements as are necessary to protect the public from hazards in their usage.

4. If required by the Secretary, a full description of the tests made and results thereof upon which claims are based.

Unless it appears on the labeling, a statement of the name and percentage of each active ingredient and any pertinent information concerning the inert ingredients should be submitted with the application for registration.

Registration is intended as a method of bringing economic poisons and the claims to be made therefor to the attention of the Department of Agriculture so that immediate steps can be taken to correct inaccurate or misleading statements before the products are marketed. Registration of a product does not mean that the Department approves the claims made for it, and registration cannot be used as a defense for commission of any offense prohibited by law.

However, the labeling of every herbicide offered for registration will be closely scrutinized and if it does not appear to comply with the law, the applicant will be advised of changes considered necessary and given an opportunity to revise the labeling.

Registration may be obtained by the manufacturer, packer, distributor, or shipper of a herbicide. When a product is registered, it may be marketed without additional Federal registration as long as it remains in the manufacturer's or registrant's original unbroken immediate container and the claims for it do not differ in substance from the representations made in connection with its registration. Blank application forms for registration of all economic poisons have been prepared by the Department and are available on request. All rodenticides and herbicides now offered for sale in interstate commerce should have been registered before shipment, and all insecticides and fungicides must be registered by June 25, 1948.

Under the law, the words "label" and "labeling" have different meanings. A "label" is defined as meaning the written, printed or graphic matter on or attached to the article or to the container or wrapper of the retail package. The term "Labeling" includes the label and all written, printed, or graphic matter accompanying the economic poison or device at any time. If the label or literature accompanying the article refers to a booklet, circular, or other literature, or directions not accompanying the article, such booklet, circular, other literature, or directions for use are included in the term

"labeling". Current official publications of the U.S. Departments of Agriculture and Interior, the U.S. Public Health Service, State Experiment Stations, State Agricultural Colleges, and other similar Federal or State institutions, authorized by law to conduct research in the fields of economic poisons, may be referred to in the literature accompanying the article without becoming a part of the labeling. It should be noted, however, that this exemption applies only to current official publications of the agencies indicated.

The label, to be in proper form, should contain the ingredient statement, the name and address of the manufacturer, registrant, or person for whom manufactured, the name of the article, the net contents, and any warning or caution statement which may be necessary. For herbicides like sodium arsenite which are highly toxic to man, the skull and cross-bones, the word "POISON" (in red) and the antidote statement are required to appear on the label. The ingredient statement, under most conditions, is required on that part of the package displayed under customary conditions of purchase, which means that it must generally appear on the front panel of the label. The law provides that directions for use must be adequate. This does not necessarily mean that they must include all possible uses of the product under all conditions. It would be difficult, if not impossible, for some products having many uses and requiring different precautions in different parts of the country. What constitutes adequate directions for use of a herbicide will vary with the product, the kinds of weeds, and the crop in which the weeds are intended to be controlled. In the case of a well-known, standardized material, it may be sufficient to include directions for the principal uses by the trade to which it will go and precautions against known dangers, together with general instructions to consult local authorities relative to use in that particular region. The directions for use may appear on the labeling accompanying the article.

If a herbicide is new or of unusual composition, it will usually be necessary, we think, to give more complete and definite directions for the uses for which the product is intended, since the user may have had no experience with it and has no other advice on which to lean. The directions given should be as specific as possible and they should be sufficiently complete so that they are not liable to mislead or confuse the user. A statement to apply where weeds are found, for example, may not be adequate, since the user may not know the hazards involved when using the particular herbicide; neither will the statement "Kills Weeds" be adequate unless modified by naming some specific kind or type of weeds that the product is intended to control. Warning and caution statements should indicate the dangers and clearly state the various hazards in-

involved in the use of the herbicide.

We are interested in seeing that the labels on economic poisons are in proper form before they are marketed. The law provides that there shall be an ingredient statement on the front panel of the label. It shall give the name and percentage of each active ingredient, together with the total percentage of the inert ingredients, or it may contain the name of each active ingredient together with the names of each inert ingredient and the total percentage of the inert ingredients, the active and inert ingredients to be stated in descending order of percentages of each one present. For herbicides containing 2,4-D, the active ingredient would be the true chemical compound, acid, sodium salt, amine salt, or ester of the 2,4-D acid expressed in percentage by weight. If the active ingredient is not the acid, the equivalent of 2,4-D acid should also be given in percentage. The active ingredient of the 2,4-D powders is generally the 2,4-D acid.

Herbicide products that are highly toxic to man, like certain mercurial preparations containing 1% or more of metallic mercury, or sodium arsenite solution containing 5% or more of sodium arsenite, must bear on the label the word "POISON" (in red) with skull and crossbones, and an antidote statement in language that is easily understood. Some caution statement should appear on the label of most herbicides. A preparation which has the hazards named may bear a statement like, "Do not breathe dust or fumes; avoid prolonged or repeated contact with the skin; keep away from children, pets, livestock, and food-stuffs." Additional caution or warning statements should be included with the directions for use on the label of products that are apt to cause injury to crop plants, flowers and shrubs. For example, herbicides containing 2,4-D may contain such statements as:

(a) Do not apply on newly seeded lawns, bent grass or lawns containing clover.

(b) Do not contaminate water used for irrigation or domestic purposes.

(c) Avoid drift of spray or dust on to susceptible vegetables and crop plants, flowers and shrubs. This is most essential where concentrated chemicals are applied by airplane or atomizing equipment.

(d) Adequate directions should be given for cleaning 2,4-D from the sprayer, hose and nozzle of the sprayer if it is to be used for other purposes.

(e) Liquid formulations that are flammable should be so marked and give warning to keep away from open flame, or avoid spraying toward an open flame.

Sodium chlorate herbicides should contain a caution concerning the fire hazard of the product when dry.

Sodium arsenite preparations should bear a caution statement like "Keep children, pets and livestock off treated areas for at least 48 hours".

Herbicide labels should contain names of typical

weeds that the product is intended to kill. Usually some weeds are included that are harder to kill than others. Such labels should contain a statement to the effect that weeds hard to kill will require one or more repeat applications during the season.

The label or labeling of herbicides should be as free as possible of such broad claims as eradicate, eliminate, exterminate, extirpate, abolish, or annihilate weeds, or reference to sterilizing soil.

Under the provisions of the act, the Government is empowered to proceed criminally against persons or firms shipping misbranded or adulterated economic poisons and misbranded devices in interstate commerce, selling or offering for sale any such misbranded or adulterated articles in the District of Columbia or any of the territories. It further provides that all such economic poison be registered with the U.S. Department of Agriculture. The Government is empowered to seize any such misbranded or adulterated articles that are being transported from one State, Territory, or district to another for sale, or, having been transported, that remain unsold, or in the original unbroken packages, as well as any such misbranded or adulterated articles which are manufactured, sold or offered for sale in the District of Columbia, or any Territory of the United States. The act further authorizes the Government to exclude from the country any such adulterated or misbranded articles, or any such articles that are forbidden entry into, or forbidden to be sold or restricted in sale in the country in which they are made or from which they are exported, or any such articles which are otherwise dangerous to the health of the people of the United States.

I realize that in this talk you have not been given answers to all the questions raised by the new legislation. Frankly, we do not have all the answers. Different problems are showing up every day and we are doing our best to solve them. We enlist the cooperation of the members of the Western Weed Control Conference in helping to maintain adequate standards for increasing numbers and types of herbicides that are being manufactured for public use.

The meeting then adjourned for noon recess.

Wednesday Afternoon

February 4, 1948

The meeting was called to order at 1:30 p.m. in the Silver Room of the Odd Fellows Temple by President Virgil Freed.

MR. FREED: Gentlemen, before we call upon the Research Committee for their report I am going to ask Chet Otis to come to the platform, please.

MR. OTIS: Gentlemen, this will be free so be at ease. This is the Conference's tenth birthday. I think that has been mentioned several times. It is

also well known to all of us that this conference is the backbone of weed control work here in the West and we have several objectives. Basically they are to disseminate information, coordinate activities and to encourage weed control activities. We have come a long ways in this ten years time. In our organization, as in any other organization, most of the work in running and sponsoring the multitudinous number of activities always falls on a few shoulders. That has certainly been true here and I think that we all know that one man, more than any other, is responsible for the huge success that we are. Not many organizations can be as proud of their accomplishments or as sure of the justification of their existence as can this one. I think you know the man I am referring to, of course, is Walter Ball, our secretary-treasurer. In consideration of these things, Walt, the few remarks and the implications behind them, we want you to know that your efforts haven't gone entirely unnoticed or unappreciated. You have done a big job and you certainly have done it marvelously well. We are going to present you with just a little, to use a trite phrase, a token of what we think about you Walt. Before we do that I would like to read just a few notes from a few letters received from various friends of Walter over the country. This is from the State of Washington. "Walt has contributed much to our cause". This is from the State of California: "Walt Ball has done a grand job in all of his work in the Western Weed Control Conference"; "Walter Ball is an untiring worker in weed and pest control". This was from the State of California also. Montana: "I just received your letter regarding a gift for Walt Ball and I heartily agree with this movement. I am enclosing a little paper money". This is from Utah: "Walter S. Ball has done an excellent job as secretary-treasurer of the Western Weed Control Conference". This is another one from California: "We feel that Mr. Ball is well deserving of a gift to express appreciation of all of us for the many years of work and sincere effort to build the Conference into the organization it is today." This one from Idaho: "It certainly is a pleasure to have a part in showing our appreciation. Walter Ball has worked so hard to make the Western Weed Control Conference a success. We certainly owe him a great debt of gratitude". (The gift, two pieces of leather luggage.)

## REPORT OF THE RESEARCH COMMITTEE

W. A. Harvey, Chairman.

The research committee has several items and several people to present, which I hope will meet with your approval. Our first meeting was held on Sunday afternoon. At that time we discussed the question of policy as to what the function of the research committee should be, and we made certain

recommendations to the executive committee which you will probably hear at the time of that committee report. There is also a separate policy committee from whom you will hear later.

This year in our research committee we had several sub-committees on particular problems. They presented reports at the Sunday meeting and at the Monday morning session. We would like to present summaries of the two of these reports because we think they will be of interest to you and we hope they will bring you useful information.

One of these sub-committees dealt with fundamental problems. As chairman of this sub-committee, I had the able help of Virgil Freed, Lin Harris, Chet Otis, Lowell Rasmussen and Dick Raynor. I have been delegated to give you a summary of our report.

We research men have realized for a long time that we do not have enough basic, fundamental information on any of our weed control methods, including chemicals. Dr. Quisenberry mentioned the same fact this morning, and we would like to emphasize it again. It has been particularly true with 2,4-D that fundamental studies have lagged behind field practices. I think we all have more field information than we can interpret because of lack of fundamental information on the action of the chemical. Without more fundamental information we have difficulty in explaining the variable results which we so frequently get in the field. I should like to at least list some of these problems which are of importance to all of us, whether we are in the research field or just applying the chemicals to kill weeds.

Any chemical used to kill weeds must do two things-- first, it must get into the plant; and second, it must exert some action on the plant which will result in the death of that plant. Both of these are fundamental problems, and on neither of them do we have as much information as we need. I am reasonably certain that many of our failures with 2,4-D stem from the fact that we don't get the chemical into the plant. And if the chemical doesn't enter the plant it can't work. More information on this point should materially increase the effectiveness of our spray treatments.

The problem of the action of most of our herbicides on plants has never been thoroughly investigated. We still do not know what happens when we kill plants with chlorates or borax or many of our older herbicides. With 2,4-D and other growth-regulating chemicals the problem is even less clear. Differences in plant susceptibility apparently lie in the actual living stuff of the cells--the protoplasm. Slight differences between plants with regard to the chemical makeup of the protoplasm itself seem to make the difference between susceptible and resistant plants. And we can't tell just by looking at the plants in the field whether they can be killed or not. But we'll have more on this point later on

our program.

There is a third fundamental problem that applies to many of the chemicals we use as herbicides, and that is translocation or movement of the chemical within the plant. Thus, not only must the herbicide enter the plant and exert an action that will kill the cells, but it must also move to all parts of the plant. Otherwise, the root system is not killed, and with perennial weeds it is exceedingly important to kill the roots. Several of the chemicals we are using today--including 2,4-D--do move within the plant. But most of us have found that 2,4-D frequently doesn't move as far as we would like--and some of the root system is not killed. Usually we find a good kill of deep vertical roots but some of the laterals seem to survive. If we knew more about the fundamentals of movement within the plant, we could perhaps do a better job of setting up conditions for spraying or of finding the chemical which would serve our purpose.

These three problems in the realm of plant physiology are basic to our successful use of herbicides. When we get more information on them we will all do a better job of killing weeds.

We have listed several other problems (some of them field problems) of fundamental importance which I would also like to mention. They include:

(1) Chemistry of the herbicide.

We need more information on the chemical properties, such as solubility, volatility, compatibility with other chemicals, and other such data before we can efficiently use the material.

(2) Resistance.

We will have the answer to this problem as soon as our answers to the three problems in plant physiology are more nearly complete. As I have mentioned, we find some plants in the field resistant because the chemical doesn't get in, others because of slight differences in the protoplasm.

(3) Application.

We need to know more about volume, concentration, pressure and droplet size for optimum results. The engineers can design a machine to do the job if we only knew enough to tell them exactly what is the best.

(4) Choice of control methods.

This is a practical problem but one which should receive more attention. With more chemicals available, it is often difficult to choose the best one for a particular problem. The tendency seems to be to recommend the newest chemical out of the test tubes. Very often, while the latest chemical may work, it may be that one of the older chemicals or older methods such as cultivation, or crop competition, or even a combination of several methods will be a more satisfactory solution to a particular problem.

These are not all the problems that face us but they are probably the more fundamental ones. When

we get answers to them we will be a long way on the road to successful weed control.

Another of the sub-committees in our group was that on field plot technique, headed by Mr. Erickson of the University of Idaho. I know that we all have problems in laying out field plots, whether we are primarily research men or salesmen, and we all want to get as much information from treated plots as possible. For this reason I have asked Lambert Erickson to give us a summary discussion of the conclusions of his sub-committee on field plot technique--Mr. Erickson:

## REPORT OF THE COMMITTEE ON PLOT TECHNIQUE

Lambert Erickson

This committee was formulated for purpose of devising methods in plot technic that would by their application produce more reliable data in weed research experiments. Plots and their replicates must be so designed that they can be truly compared to one-another if the resulting data is to bear statistical analyses.

The committee recommends no specific plot design for weed research plots since the design will be largely influenced by the area available, the weed type, and the particular information sought.

Since the data obtained in any study using 2,4-D as a selective or non-selective herbicide will be influenced by the time permitted to elapse between the time of treating and the time of reading, the committee suggests the following procedure with reference to making reading. A few additional general suggestions with reference to plot technic are also included.

1. When to make recovery readings on treated annual weeds.

A. Permit not less than six weeks to elapse between the treatment and reading, i.e., late enough to determine percent recovery of plants treated. Harvest time is satisfactory unless difficulty will arise in determining which might be new seedlings.

2. When to make recovery readings on treated perennial weeds.

A. Make readings in year following treatment.

Minimum 1 month after growth commences and maximum bloom stage.

(1) The committee again cautions that re-growth readings on perennials should not be made in the year the treatments are applied.

3. How to take readings.

A. Get a detailed count--if plots are large make 3 to 9 sample counts.

B. Method used should be determined by the procedure that will give the investigator reliable data.

C. The rank method is useful, but do not use it where you want detailed information. Remember that



the rank method hides differences.

#### 4. Replications.

A. A replication is one series of treatments. This might include, for example, one material at several rates, or several materials at one rate.

B. Replication is necessary because there will in nature always be differences between replications. Replications are necessary to get a measure of variation.

C. Precision is usually increased faster by increasing the number of replications than by increasing the number of samples.

#### 5. Time-Years.

In addition to good replication practices, replication of years is necessary to determine the effect of season upon the treatment. Three years is regarded as a minimum in this respect.

6. a. In addition to replication, the experiment should be so designed that the results or data can be statistically analyzed.

b. A second benefit of planned experiments is that factors within the experiment can be segregated out for special study.

7. Even statistically significant results from one season's work must not be considered as unalterably true. Not less than three years is required for reliable interpretation of data for field results for the given area represented.

8. Significant differences between treatments are difficult to obtain in selective weed control work because of a greater inter-relation of factors than in singular crop or weed studies.

MR. HARVEY: We have two other fellows on the Research Committee whom I would like to present to you. Both are new to our conference. The first is an authority on plant hormones and the current interest in 2,4-D and some of the other weed killers which are recognized as being hormone-like materials makes him of special value to us. Much of the physiology of the fundamental problems I mentioned to you can be approached along the same lines that the hormone physiologists have been following for some time. This gentleman is a member of our research committee. He was with the California Institute of Technology and since that time has been in Puerto Rico at the Experiment Station. He is now with the Shell Agricultural Laboratory at Modesto. I would like to ask Dr. van Overbeek to give you a little information on action and translocation of hormones in plants.

DR. VAN OVERBEEK: It is known that the most effective poisons are found among those compounds which resemble, in terms of molecular structure, some hormone, vitamin or other substance necessary for the life of an organism. Thus, for example, it is believed that the sulfa drugs are such effective bacteriostatic agents because their molecular struc-

ture closely resembles that of para-amino-benzoic acid which is an essential growth factor for many micro-organisms. Due to structural similarity of the molecule the organism cannot distinguish between the growth inhibitor and the growth factor, and soon the active groups in its protoplasm are saturated with the inhibitor, to the exclusion of the growth factor. This stops the normal function of the protoplasm and thereby prevents growth.

The effectiveness of 2,4-D as a phytocide is probably based on somewhat similar principles. There is ample evidence that in low concentrations 2,4-D acts like hormones of the auxin type. Like these auxins 2,4-D in concentrations of the order of 5 to 10 parts per million is capable of causing growth curvatures in leaf petioles, of preventing preharvest drop of apples, and of inducing flower formation in pineapples. However, the 2,4-D concentration of 250 parts per million will wipe out by one single spray application 80% of the weed population of the most common sugarcane weeds in Puerto Rico.

What is it that makes 2,4-D so effective? In the first place it appears that 2,4-D, due to its close resemblance in molecular makeup to natural auxins, is readily taken up by plants and transported along their normal channels of hormone transport. Experiments at the Bureau of Plant Industry have made it likely that the substance is taken up and transported in the molecular non-dissociated form and that it is transported away from the leaf, to which it is applied, to the growing and other regions of the plant in association with the translocation of sugars and along the same course. These observations have important practical implications, viz., alkaline sprays in which the major part of the 2,4-dichlorophenoxyacetic acid occurs in the ionized form are less effective, and any action which prevents the leaf from normally translocating its sugars will also tend to prevent the spreading of the herbicide throughout the plant.

In the second place, 2,4-D is an effective phytocide because after its molecules have been transported along the regular channels of hormone transport, they will arrive and apparently accumulate at the site where the natural hormones are most active, i.e., in the protoplasm of the growing meristematic zones. This has been directly demonstrated by the Bureau of Plant Industry in experiments with a growth regulator containing radioactive iodine.

The normal function of hormones in the protoplasm is not exactly known, but there is good evidence that plant hormones regulate enzyme processes. In this respect plant hormones resemble animal hormones. Among the enzymatic processes which plant hormones affect are some processes of respiration. Recently two Chinese workers have given us evidence that the toxic effect of 2,4-D may be due to its interfering with aerobic metabolism. They pointed out that rice,

which is capable of anaerobic germination, is little inhibited by 2,4-D, while barley, which will germinate only under aerobic conditions, is strongly inhibited by 2,4-D.

It appears, therefore, that 2,4-D owes its effectiveness to its capacity to penetrate, in a physiological fashion, into the protoplasm of the meristem, thereby upsetting its normal functions, perhaps by interfering with aerobic metabolism. It is well to remember that meristems are among the most vulnerable parts of the plant, but often are so well protected by their location within the plant that they cannot be reached by contact sprays. It is only because the hormone weed killers invade the plant through its normal channels of transport that these well hidden meristems are being reached. An example of this is the cyperaceous weed *Cyperus rotundus*, known as nut grass in the United States and as "coqui" in Puerto Rico. Its meristem is hidden well below the surface of the soil and in addition, is enclosed within the base of a structure which resembles a stem. No previous effective means of control existed for this weed, which in certain localities in the tropics is a major pest, but with 2,4-D complete eradication has now become possible.

In what manner could one visualize the effect of 2,4-D on aerobic metabolism? Some scattered experimental data are available. With the aid of these, together with information obtained in related fields, an attempt can be made to come to at least some tentative understanding of the action of 2,4-D on the metabolism of the plant cell.

Goddard, in a clarifying chapter on the utilization of liberated energy, states: "In many of the synthetic reactions of growth an increase in free energy occurs, and such reactions may only occur if they are coupled with an oxidative reaction furnishing the energy deficit".... "This widespread oxidative assimilation must be at the very basis of the chemistry of growth." Oxidative assimilation occurs in growing cells more frequently than in non-growing cells, and seems much more striking in plant than in animal cells. The fact that 2,4-D is toxic especially to growing cells and is specifically toxic to plants becomes understandable once one correlates the action of 2,4-D with oxidative assimilation.

The energy liberated in oxidation is utilized for the work of the cell. The energy coupling involved is the central problem of cellular respiration. One way in which the energy transfer can take place is by transfer of phosphate. Wildman and Bonner have recently linked auxins to phosphate metabolism. From spinach leaves an auxin protein was isolated which appeared to have phosphatase properties and which could rapidly hydrolyze a number of phosphorylated compounds. Since it has been shown that 2,4-D has many properties of natural auxin it would not be surprising if 2,4-D, after combining with suitable

proteins, would likewise be capable of stimulating the liberations of inorganic phosphate from phosphorylated compounds. This may involve direct release of phosphate bond energy (which would be lost as heat) or transphosphorylation. Perhaps it would do so more strongly than the natural auxin indoleacetic acid. One reason for this would be that, as with hormones in general, indoleacetic acid is constantly being inactivated in the organism. Thus it has become known recently that an oxidase exists which specifically inactivates the natural auxin indoleacetic acid. Many synthetic auxins would escape such inactivation. It is a fact that 2,4-D ranks among the auxins which persist longest in the plant. Perhaps there are also other reasons why 2,4-D would be a stronger agent in the hydrolysis of phosphorylated compounds than native auxin.

An exaggerated energy release in the organism may have far reaching consequences and may lead to the complete cessation of growth. A possible mechanism was suggested by McElroy:

"If inorganic phosphate is increased greatly by the hydrolysis of some phosphorylated intermediate (breakdown of high energy phosphates), then the glycolytic reaction may be so stimulated that the oxidative processes concerned in synthesis may not be able to compete with the available hydrogen acceptors and are consequently inhibited."

Here then we may have a biochemical basis for the understanding of the herbicidal action of 2,4-D. It now becomes understandable why the toxic action of the compound is slow. It also becomes understandable why, due to 2,4-dichlorophenoxyacetic acid, respiration, starch hydrolysis and depletion of food reserves are increased, while at the same time the growth process is inhibited. A somewhat similar case is known for sea urchin eggs where it has been found that dichloronitrophenol and other substituted phenols will completely inhibit cell division, while at the same time respiration is markedly increased.

MR. HARVEY: Thank you very much Dr. van Overbeek. The next gentleman whom I would like to present to you is Dr. F. E. Hance from the Hawaiian Islands. He is with the Hawaiian Sugar Planters Association, and we have felt, in our research committee, that as long as we are a western states committee that there is no use interpreting the term "West" too closely. As far as we are concerned the Hawaiian Islands belong with the western states and Dr. Hance belongs with us. He has some problems which I think you will find a bit different than you are accustomed to. He is using some of the same chemicals and I am sure you will enjoy a brief discussion by Dr. Hance of some of the problems and methods of weed control in the Hawaiian Islands. Dr. Hance:

DR. HANCE: Gentlemen, several references were made

this morning to Mr. Noel Hanson of the North Central Conference. Is that right? Well, in any event, he has traveled from Lincoln to Honolulu and is helping us in our herbicide interpretations in Hawaii and also in applications of herbicides but I understand that before he left Lincoln to go to Hawaii some of his colleagues presented him with a large pair of paper shears in order that he could more efficiently handle the grass skirts on the hula girls. Now when his plane came in I didn't know he had those scissors in his grip--in fact I didn't know he had them at all, but I think he has found out by now that the scissors won't do him much good for this reason--a good many of those grass skirts are held up around the waist with rather loose connections. The waist band holds up the grass and in some cases with quite a number of fancy coconut shell buttons right around the waist band. Now he's going to find out that one of those buttons is not there for ornamental purposes. Now, Gentlemen, I have until almost half past two to get over to you what I have to say. I have one little sheet of paper--that's all, and on it I have nine topics which I think you would be interested in, and I also think you will be interested when I tell you I am not going to discuss any one of them too long.

The first thing I have here is a topic that is very important to us. There is no season on weeds in Hawaii. You have that here in California, too, I heard some time ago, but we have weeds down there 12 months a year, two kinds of weeds: grasses and broadleaf weeds. Forty years ago when contact weed control first came into being in Hawaii we used an old stand-by herbicide. I'm not going to tell you what it was but I'll bet you all know. We used an old type herbicide which, at that time, was very cheap. You know what it is--well, anyway, what happened was this: we applied that contact herbicide rather generously and, in the early days, we had about 50 per cent broadleaved weeds and 50 per cent grasses. For 40 years, or almost 40 years, that practice has been going on and I guess you know the results. We would kill out the annuals completely and the grasses only above ground. The grasses would recover, start to grow up in the bare spaces where the annuals were before, and hence our problem today is not weed control--it's grass control. Now on these grasses I want you to know I'm not talking about the stuff you fellows have in your front lawns--that little short tender stuff. Oh no, you should see our grasses. We've got grasses that grow from 12 to 15 feet high straight up, no fooling, and I wish you could see the covering of some of those grass stems. I want you to know, the bottoms of some of those stems look as though they had bark on them. An ordinary herbicide won't phase them.

The next thing I would like to mention (if I were giving you a regular paper) would be something on

Diesel oil. What it was 20 years ago, how we used it then, and how it is used today. The point is this: a maximum concentration of the lethal substance in a herbicide, to us, is absolutely essential. I will illustrate it this way. We have a preparation in which I have a personal interest. We call it CADE. It is simply this--CADE implies a concentrated activated Diesel emulsion. It is an emulsion of Diesel oil and water in which Diesel oil is present to the extent of 67 per cent. A companion preparation is a water solution of sodium pentachlorophenate and wetting agent. We call it SSA--stock solution of activator. One hundred gallons of the emulsion CADE and 50 gallons of the SSA are diluted 1 in 16, using water from a ditch in the cane field where the herbicide is to be applied. That amount of concentrated stock material will keep 12 men going all day long in knapsack weed control. So you see the advantage of having that contact herbicide concentrated. You would understand the situation more completely if I had time to explain.

The next point that I would like to discuss is the H.S.P.A. system of activation. I think we have shown definitely and conclusively that by activation we do get a synergistic effect from the activator (sodium salt of pentachlorophenol). What we think takes place is this--that by adding 1 per cent, or rather between one and one-fourth or one and one-half per cent of the sodium pentachlorophenate to this diluted CADE, we get an effect from the Diesel oil in the CADE far greater and more lasting than we could get were we using either Diesel oil or activator separately or individually. I don't think there is any question about that. This is the H.S.P.A. system of activation in a nutshell.

Now we come to the harmful effects of 2,4-D as we found them in Hawaii, and believe me, they are harmful if not properly controlled. When we harvest a field of cane, the field is plowed and harrowed and seedpieces are put in for the next oncoming plant crop. Most of these seedpieces are placed about 4 inches below the surface of the ground and planted in rows 5 feet apart.

Now, we'll say we are going to make a pre-emergence herbicide application. Incidentally, you gentlemen don't have much to say about pre-emergence work here in the West, but believe me this is a major topic with us. In a pre-emergence application of 2,4-D in a cane field today, remember that seedpieces have been planted 4 inches beneath the surface of the ground. Those of you who haven't seen a seedpiece of sugar cane, if you cut off about that much of a broomhandle, that is what it would look like. Now there it is down there, 4 inches below the surface. We come along and put 10 pounds of 2,4-D, we'll say, in the solution of water and a little alkali. We put 10 pounds of 2,4-D over one acre of the bare surface of that field, just 10 pounds. Now, depending

on the type of soil and the uniformity of that application, we get two results. One of the results will be good. I like it very much; it stops the germination and growth of surface weed seeds perhaps for a period of 6 or 8 weeks or even 2 or 3 months. But at times it does something else (that little bit of 10 pounds of 2,4-D) on an acre of bare soil. In some Hawaiian soils, receiving 10 pounds of 2,4-D per acre, 50 to 60 per cent of the seedpieces either will not germinate or, if they do germinate, in many cases the shoots coming out, instead of coming up straight, may grow a spiral like a pig's tail. The root system, in such cases, instead of being long, fine and normal, will develop thick, stubby, bleached, quill-like growths. Other Hawaiian soils in sugar cane lands will take up to 25 pounds 2,4-D per acre without the appearance of the abortive growth just described. However, we have found that the H.S.P.A. Activator, if used in pre-emergence at 40 pounds or more per acre of bare soil, will function just as well as 2,4-D without creating any abortive effect upon planted sugar cane seedpieces in any soil.

Furthermore, if the activator is used to supplement a markedly reduced quantity of 2,4-D in a sensitive soil, the results obtained are entirely satisfactory on a weed control basis without any injury to the planted seedpiece. The chemicals are dissolved in a highly aromatic petroleum oil. In using the above oil solution, we think this is happening: that the oil, heavy aromatic oil, will function not only as a solvent for 2,4-D and the activator but, being an oil, it will tend to stay on the surface of the ground and resist the leaching action of rains and irrigation water and hold the effect on the surface of the ground, where we want it, anyhow. We have gotten very good results so far in experimental work along this line. I haven't heard anybody describe a compound of 2,4-D with another substance as the activator in your pre-emergence plans. It might be old stuff to you, I don't know, but it looks very good to us. Now gentlemen, I will place such a formula on the board. I am going to call this "Hi Vol". Somebody was telling me about a preparation they call dynamite. "Hi Vol" stands for high voltage.

The "Hi Vol" Formula, or "2,4-DAC" (Pre-emergence)

66 lbs aromatic petroleum oil (a by-product of a T.C.C. cracker)

10 lbs H.S.P.A. Oil Soluble Activator (pentachlorophenol)

2.5 lbs Isopropyl ester of 2,4-D (equals 2.1 lbs 2,4-D acid)

2 lbs oil soluble emulsifying agent (any good one)

Makes about 10 gallons.

Dissolve activator in oil with gentle heat. Remove heat and add ester and emulsifying agent. Stir. Dilute 10 gallons above with from 40 to 90 gallons of water. Agitate and apply. This is sufficient for 1 acre of bare soil.

This formula is also an excellent contact herbicide.

You notice we cut our 2,4-D from 10 pounds actually down to 2.1 pounds; I am using the ester of 2,4-D. We are including 10 pounds of oil soluble activator. Now, the activator has an effect on sugar cane root systems and the growth of sugar cane which I didn't mention. The oil soluble activator actually appears to stimulate root development and cane growth. It also functions in pre-emergence almost as well as 2,4-D. We have applied treatments which will last from 8 weeks to 3 months. At the end of that time we go through the cane with a CADE application, the contact herbicide, and perhaps before the cane closes in, there will be another application of CADE.

Now there's another point I would like to mention to you men who are doing research work. If you haven't found it out already--when you make up a formula like the one above, when you use the ester of 2,4-D you will find that the ester will dissolve about 20 or 22 per cent of the oil soluble activator. It's an excellent solvent for use in other formulations. You can also move that 84 per cent, 2,4-D in the ester up the line and get it into the 90's by dissolving 2,4-D acid in the ester if you want to do it.

I think the clock shows about 3 minutes to go. I'll stop now. Thank you very much for listening.

MR. HARVEY: Thank you very much, Dr. Hance, I am certain we all enjoyed the talk from our fellow western colleague. I would like to emphasize one of the points which Dr. Hance discussed. That is the change in weed flora as the result of using one particular method of control. As he mentioned, persistent use of one particular chemical changed their weed flora primarily to grasses, which are quite difficult to control. That is important to consider in all of our work--using one particular method of control to the exclusion of others. It is one of the reasons that I mentioned under fundamental problems that a choice of method or combination of methods frequently has advantages over one method alone. I think we have a little indication in California that our wild oat problem may be getting worse in some of our grain lands where we are getting good control of mustards or radish and have been for several years. There may be other factors in the spread of wild oats, of course.

Now the last item that the research committee has on the program. There was very little opportunity when Lou Evans gave his talk the other day on new herbicides for questions about these new materials, so we have asked Lou to come back and lead the discussion, if he will, on these newer herbicides. We have several other fellows lined up who will probably tell you about some of the specific materials. However, if you have questions about some of the chemicals, now will be your time to ask. I'd like to mention, and he will probably tell you the same.

thing--that on some of these new chemicals we don't have nearly all the answers but we do have some indications which we hope might be helpful to some of you working in the field. They are not recommendations--especially on some of these newer things--they are just suggestions and ideas from the limited amount of work which has been done to date. Lou Evans:

MR. EVANS: I had my day in court on Monday so I'm not going to attempt to rehash everything I said at that time. I have gotten an impression from some of the questions that have been asked today that a good many people are anxious to ask questions on some of these newer things. I don't propose to answer all of your questions but I think that you have enough experts here in the audience who will probably give you the answers so far as the information is available at this time. I don't know how much time we are going to have here but we will make it as short as you like and make it as long as we can answer questions. While we are waiting for some of these questions to crystallize in your minds, I might mention in connection with what Dr. Hance said that we must consider in the use of 2,4-D that we are having a serious increase in our grass population. That is something to think about.

QUESTION: The other day you told us that ATA on quackgrass in alfalfa injured the alfalfa. How much damage does it do?

MR. EVANS: The question is--how much injury to alfalfa when ATA is applied for controlling quackgrass. Vic Bruns, I believe, can answer that.

MR. BRUNS: The applications of ammonium trichloroacetate were made about the middle of August on alfalfa and vetch growing in the orchard as a cover crop. We put on the applications of ammonium trichloroacetate and the alfalfa and vetch were burned down. After about two or three weeks the alfalfa and vetch came back. Now, how much injury was done to the alfalfa I do not know yet and can't tell for sure until spring. Applications ran all the way from 1/8 to 1/2 pound per 100 square feet or 55 to 220 pounds per acre. It appears to have possibilities, however, and we will try to follow up on that.

MR. EVANS: OK--any other questions?

QUESTION: The question was asked about ATA. Is that the same as we saw in the flats at Davis?

MR. EVANS: ATA is ammonium trichloroacetate. The material you saw in the test yesterday was the sodium salt of trichloroacetate.

QUESTION: What was your kill on quackgrass?

MR. EVANS: We won't know definitely until this coming spring, but the original kill of the top ranged from 90 per cent or more from applications of 110 pounds and up.

QUESTION: I noticed at Davis yesterday some of what I took to be pre-emergence post planting applications of IPC. I would like to ask someone how that was put on uniformly at the rate of 1 pound per acre.

MR. EVANS: I think that question probably can be answered by Bill Harvey.

MR. HARVEY: If you have pure IPC, it is a difficult soluble. We have two different wettable types of IPC; the one that we applied on those tests was an 80 per cent wettable powder which handles much like wettable DDT. It stays in suspension if you keep it agitated. We haven't had too much trouble on small plots if we kept the solution well agitated. I see Luther Jones who is our alfalfa man at the College, back there. He's actually done most of the work on alfalfa. I helped him mix solutions but he does the hard work in the field. Luther, would you like to say something about some of these tests on alfalfa?

LUTHER JONES: I don't believe I have anything to add.

MR. HARVEY: We have done quite a lot of alfalfa work here in California because with this extensive growing season we frequently get an awful lot of weeds in the spring before the alfalfa starts up. We have a rather regular program of alfalfa spraying while it is dormant, with an oil fortified with a dinitro or pentachlorophenol mix. This doesn't take care of some of the weeds that start up and it frequently doesn't take care of all of our grasses unless we use a high amount of oil. We are trying to get rid of some of the oil we now have to use by using another type of grass killer. We also are trying to get a better residual toxicity in the soil to keep down later growth before the alfalfa comes along.

OFFORD: IPC is soluble in tributylphosphate but there is some question of toxicity of the tributyl phosphate to the operator.

MR. FREED: Tributylphosphate is somewhat toxic and it is not a cheap solvent. We have formulated IPC with various solvents. The cheapest and the one I like the best is the monobutyl ether of the ethylene glycol. You probably know it as butyl cellosolv. It is miscible with oil and soluble in alcohol, acetone, dioxan and other organic solvents. That would be the pure IPC and not the wettable powder.

QUESTION: On 2,4-D, what is high gallonage and what is low?

MR. EVANS: The question is, where are you going to set the limits on what is high gallonage application and what is low gallonage application of 2,4-D. This question was asked yesterday and we were assured the question would be answered today. I think they were just putting you off. I don't think anyone is prepared to answer it.

MR. DENNISON: We have applied as high as 25 pounds of 100% acid of 2,4-D to the acre without any detrimental results to sugarcane, on pre-emergence. That means before anything had come up. When we speak of pre-emergence in Hawaii we mean before the weeds have come up, not the crop you are going to harvest. We refer to it in the light of the weed itself rather than the crop because it is a contact spray if the weeds are growing, and what we try to do is to prevent the weeds from coming up. We have used as high as 25 pounds per acre successfully but we have also had trouble with as low as 1 pound per acre. It depends upon the soil type. I am not prepared yet to give you a full answer on the soil type but we know definitely there is something to look into there. Maybe it is closely related to phosphate fixation in soil whether you are going to get detrimental results from the use of 2,4-D.

MR. EVANS: Mr. Dennison, did you mention at what volume the chemical was applied?

MR. DENNISON: 300 gallons of total material to the acre.

MR. EVANS: That is high volume.

MR. DENNISON: We go up to 500 gallons per acre of spray.

DR. HANCE: If we put it on at 5 gallons per acre we would call it low volume.

MR. EVANS: In regard to the question of 2,4-D in low volume, one publication from South Dakota said that 2,4-D cannot be used in areas where water is so short as to make low volume applications impractical. My comment is water really must be short there. Being in a position of an outsider, I do not feel that I should attempt to answer the question in so far as fixing the limits of high and low volume. I believe that is something for you people here in the western states to do.

MR. FREED: Relative to low volume or high volume, I think the volume applied per acre is going to depend on the equipment you have available, the type nozzle, etc. as well as the water problem. Some of the machines are not equipped to put on 4 gallons per acre uniformly; others are. I do not think the

Conference or any of the research members would be willing to go on record as recommending the exact gallons to apply 2,4-D without knowing the type of equipment that was going to be used. I wouldn't even do that for the State of Oregon.

MR. EVANS: The point is well taken, I think, and I wonder why we need to definitely fix the limits at this time on what is high and low volume. In a sense it is an academic question.

JIM MEYERS: I have had a little experience with low volume and I would like to say this. I think that low volume, as we call it, depends entirely upon how uniformly the material can be distributed over an acre without danger. That depends upon the equipment being used and upon the men using it. We have successfully applied 2,4-D on several hundred acres at 2.2 gallons per acre, and on several thousand acres at 3 to 5 gallons per acre, and we will contend it depends upon the care with which it is applied.

MR. EVANS: I think you will find that a good many people would agree that it is not as much a question of gallonage as it is a question of distribution--of how low you can get low volume equipment to give you satisfactory distribution.

MR. FREED: I think Mike Huber and Jeff Rogers would bear me out on this. They would like to know the answer. How can you apply extremely low volumes, 5 gallons or less per acre, without danger to drift? The point is this--our wheat area customarily has gentle breezes blowing all spring, starting out at 10 to 15 miles per hour and working up from there. How can we avoid drift of low volume applications under these conditions?

MR. MEYERS: If I could answer that question, I would say this: That at low volume I have seen pressures between 20 and 30 pounds. I have taken hundreds of feet of Kodachrome film, which seems to pick up drift better than the eye, and I have made this discovery--that 3 gallons per acre at 20 pounds pressure has no greater drift than 75 gallons at 60 pounds.

MR. EVANS: I think we should go along to another subject if we are to finish on time. We have already had some mention of aromatic oils. I think it might be appropriate at this time to call on Frank Herbert of Shell, who will give us a few remarks on that subject.

MR. HERBERT: I would like to make a little statement here about the four different oils that Shell's Agricultural Laboratory has developed. We have No. 10, 11, 20 and 30. Probably those are somewhat confusing by numbers. No. 10 is a carrot oil which is

a high solvent type oil, replacing in a large degree the stove oil that has been used heretofore on carrots. Its greater safety is that it normally leaves no taste after 30 days of warm weather, but we play safe and say 40 days, whereas stove oil takes from 75 to 90 days and sometimes longer. It takes out some of the weeds that stove oil does not, like Russian thistle, and has been generally effective at lower gallonages than stove oil. We have sprayed over the tops of the beds for carrots. We go down to 35 gallons and maybe 50 gallons. When we are going out to spray the whole surface it may take 60 to 80 gallons per acre, depending on the size of the weeds. On celery we found it much safer in the seed beds than stove oil. We go as high as 75 gallons an acre on the cotyledon stage of celery without injury whereas stove oil at the same dosage would take out practically 100 per cent of the plants. We do not recommend it on celery because celery isn't always transplanted; but say transplanted celery 3 to 4 weeks after transplanting. If you put it on after that you are liable to get a funneling of the oil down into the center of the celery. That doesn't always apply. We saw some put on peat soil and six weeks after transplanting there certainly wasn't 100 per cent of the crowns hurt, but growers said that something like 5 to 10 per cent had been taken out of the whole field.

We have another light type oil for use on flax. It will take out the small broad-leaved weeds but is made particularly for wild oats and canary grass. It is used normally at 80 to 90 gallons per acre. We get some yellowing in flax at that gallonage but the flax comes back and stools out very nicely even if you burn the tip out. Sometimes it is a good plan to burn the tips out since you get more stooling and more crop. We got as high as 40 per cent increase in flax in these fields where grasses had been a problem. We treated when the flax was 8 inches in height but we like to get the grass as early as possible. It is merely a stop-gap during these high prices on flax. Flax price went up from \$6 to \$8.40 a bushel last year; last week flax was \$7.50 a bushel and the prediction of the Association is that it will go to \$9 this year. The grower is able to put on 80 to 90 gallons at that price.

QUESTION: Does that work on fiber flax as well?

MR. HERBERT: It does shorten the fibers, I would say. It has no detrimental effect apparently on the seed plants. We sprayed this year about 1000 acres in the Imperial Valley with pretty satisfactory results and apparently Arizona is doing about as well.

Our #20 oil is a high aromatic, all-purpose weed killer, which we figure is about two to three times as toxic as diesel oil. It is applied at 20 to 30 gallons per acre as a pre-emergence spray. I have

seen fields sprayed with 25 gallons per acre and covering about 50 per cent of the surface, which gave very satisfactory control. Other applications have been made on small annual weeds, 100 gallons to the acre. When we are after Bermuda grass we recommend about 300 gallons per acre. I have taken out practically 100 per cent of a Bermuda grass infestation with 300 gallons per acre. I realize that most infestations of Bermuda grass will require several applications. We are using this same material as a selective spray in alfalfa. In some instances we have taken out the annual weeds with 30 to 60 gallons per acre during warm weather. In the Antelope Valley in southern California it will take sandbur out of alfalfa after the second and third cuttings at 75 to 90 gallons per acre. The alfalfa comes back and produces a crop as heavy as if no oil had been applied. On Bermuda grass and Johnson grass the best results have been from further south. We have applied as high as five applications on Johnson grass without eliminating it. Work in Arizona of two applications of 160 gallons per acre, four weeks apart, the third application of about 40 gallons, and a fourth application of about 20 gallons has, I understand, pretty well eliminated the Johnson grass. Important here is Weedkiller #30 which is a fortified oil containing pentachlorophenol. It is new and is being tried out in an emulsion containing 5 to 15 per cent of the oil in water. In some cases as much as 20 per cent is used. We are doing some work blending #20 with #30 where the large amount of pentachlorophenol is not needed. Shell #30 has 15 per cent pentachlorophenol dissolved in the oil. The lower dosages are normally used upon broadleaved weeds and the higher dosages on grasses. Grasses are the toughest and the hardest to kill. I think this covers the situation pretty well from our point of view.

MR. EVANS: Thank you, Mr. Herbert. I think we should call on another of the oil companies for their contribution. Mr. J. M. Bell of the California Research Corporation--

MR. BELL: Thank you. What Dr. Herbert has just referred to is an illustration of research by industry which Dr. Willard mentioned this morning. The oil companies are able to support research which has been responsible for the products discussed. There is also very healthy competition within the industry. My company, Standard of California, is, for example, a keen rival of Mr. Herbert and his group. As a result of that all of you benefit by continually improved products and increased uses for those products. I might point out that the oils are particularly beneficial for the control of grasses, inasmuch as they are able to creep and penetrate and get down into the growing point. These products, although they have been introduced since the last

meeting at Portland a year ago, have been field tested very thoroughly in California and Arizona and they have been described in some of the California Extension Service Circulars. Standard of California has a selective oil, Standard Weedkiller #1 which has been found adapted to the uses mentioned by Dr. Herbert for his product. We are also very encouraged by the way it takes care of fern asparagus. The selective oils are described in California Circular 136. The general contact weed killer, Standard Weedkiller #2, is described much more thoroughly than we could do at this time, in California Extension Circular 137. I am sure, if you are interested in the use of these products, you will find them described thoroughly there or you can consult your county or state agencies. You can look to the petroleum industry for us to keep our shoulders to the wheel and enlarge the uses of the products that are already available and to furnish new ammunition for our common battle against weeds. Thank you.

MR. EVANS: We haven't heard yet from the General Petroleum representative. If there is someone in the audience from the General Petroleum Company, we should be glad to hear from him. Apparently there is no one from General Petroleum here. Is there a representative of the Associated Oil Company who would care to discuss their products? In the absence of any further discussion, we had better go ahead with the business of the Conference.

MR. HARVEY: Thank you, As chairman of the Research Committee for this year, I would like to introduce my successor, Chairman of the Research Committee for next year, Dr. L. W. Rasmussen of Washington State College.

## REPORT OF RECOMMENDATIONS COMMITTEE

H. E. Morris, Chairman

The Committee emphasizes that the suggestions in this report are to serve as a tentative guide, and that they are not meant to replace State or Local Recommendations. The effectiveness of herbicides depends upon many variable factors. Definite amounts, for variable environmental and plant conditions, cannot be given to fit all localities existing in the 11 States of the Western Weed Control Conference.

Herbicides are conveniently classified according to the following types:

1. Growth Regulating Herbicides
  - a. 2,4-D Derivatives, I P C
2. Petroleum Herbicides
  - a. Selective and Contact

3. Dinitro Herbicides
  - a. Selective and Contact
4. Soil Fumigants
5. Soil Sterilants
  - a. Chlorates
  - b. Arsenicals
  - c. Borax
  - d. Ammate

*Good farming practices form the basis of recommended weed control. All other methods are supplemental to good farming and to each other.*

1. Growth Regulating Herbicides
  - A. 2,4-D (2,4-dichlorophenoxyacetic acid) Derivatives

2,4-D preparations now on the market are of three general types: (1) inorganic salts; (2) amine salts; and (3) esters.

The ester forms usually appear to be slightly more effective than the salts, especially under unfavorable weather conditions and upon the less susceptible species.

All forms can be used either as a spray or as a dust. Dusts should be used only under favorable conditions, when the humidity is high, and practically no wind, and in areas away from susceptible crops. Care must be taken to prevent drift, and consequent injury to adjacent crops.

2,4-D may also be used to control or eradicate many weeds, and some woody plants. However, plants vary widely in their reaction to 2,4-D. Some are very susceptible and others, highly resistant. A list of plants classified as to their reaction to 2,4-D should be consulted, before attempting weed control.

Most grasses are highly tolerant to 2,4-D. Therefore, certain weeds occurring in grain fields or corn may be killed by the use of 2,4-D sprays or dusts without seriously injuring the crop plants.

2,4-D can be used successfully in selective spraying in the following crops: cereal crops and seedling or perennial grasses to control certain annual, winter annual, biennial, and perennial weeds.

Certain varieties of flax have been successfully sprayed with 2,4-D for weed control. It is recommended that the use of 2,4-D on flax should be strictly on trial basis in 1948, as flax varieties vary widely in their reaction to 2,4-D.

2,4-D can be used effectively in general spraying on land not in crop for the control of many annual, winter annual, biennial, and perennial weeds and some woody shrubs and trees. Higher rates may be used than when the weeds are treated in a growing crop.



Since the rate of application of 2,4-D varies from  $\frac{1}{4}$  to 1 pound parent acid per acre in treating weeds in growing crops and up to 2 pounds or more elsewhere, it is recommended that definite and specific recommendations be secured from local agencies such as County Agents, Weed Supervisors, State Departments of Agriculture, Agricultural Experiment Stations, Extension Service, etc.

The amount of water used per acre in applying 2,4-D varies within wide limits, i.e., five gallons or less to 200 gallons. The important thing is to get uniform distribution of the chemical over the area sprayed. The amount of water to use will depend upon available equipment and the size of the area to be sprayed and certain other factors. Low gallonage spraying requires special equipment and accurate control. Under favorable conditions good results are obtained by aeroplane spraying or dusting.

The aeroplane is used almost entirely for special conditions such as spraying rice fields--large grain acreage, sage brush areas, water courses etc.

2,4-D as usually recommended for the control of weeds is not seriously harmful to soil; it causes only a temporary sterilization of the surface soil. Soil type, soil moisture, and soil temperature are factors which influence the effect of 2,4-D on soil. This will vary widely under different conditions.

Cattle, sheep, and horses show no ill effect when grazed on vegetation which has been sprayed with 2,4-D and available evidence indicates that 2,4-D is harmless to humans.

#### B. IPC (Isopropyl-n-phenyl carbamate)

IPC is a growth-regulating type of chemical, which has shown some toxicity to grass plants without serious injury to certain broadleaved plants. It is not recommended for the control of perennial grasses such as quack grass. Further testing is necessary to find out its possible use.

### 2. Petroleum Herbicides

#### A. Selective

Selective petroleum herbicides are used principally to control weeds in carrots and related crops. The improved oils (Solvents and thinners), although more expensive, are superior in many ways to stove and other oils. Apply just enough oil to wet the plants. Young carrots are usually treated in the 1 to 4 true leaf stage. Highly refined oil may be used up to within six weeks of harvest.

#### B. Contact

Contact petroleum herbicides are used to destroy all kinds of vegetation. These herbicides

are used to control unwanted plant growth along highways, rights-of-way, fence lines, etc.

The oils used include Diesel oil, stove oil, kerosene distillates, fortified oils, and fractions high in aromatic content sold as contact weed killers.

These oils vary considerably in their toxicity and each has its advantages and disadvantages for particular purposes. Each grower must determine for himself on the basis of available information which type of oil is best for his use after he becomes familiar with the qualities of the various oils.

Hard and fast recommendations cannot be made to cover all conditions; therefore, consult local soil fumigants is confined largely to high productive land and for spot-treating isolated plants or small areas in a field which has been given some other weed control practice.

The principle soil fumigants are carbon bisulfide, chloropicrin, and prochlor. They should be used according to the recommendations on the container.

### 5. Soil Sterilants

Soil sterilants kill by creating a toxic condition in the soil, the duration of which depends on the chemical used, the quantity applied, the soil type, organic material content, rainfall, etc.

#### A. Chlorates

Chlorates are usually recommended for the treatment of small areas of perennial weeds when complete eradication is desired, and partial soil sterility for two or more years is not objectionable. The recommended rate of application is from 3 to 6 pounds of the chlorate per square rod. It may be applied either as a spray or in a dry form. Two or more applications are necessary for complete control. There is a fire hazard in connection with the use of chlorates, especially when used as a spray, and due precautions should always be taken in using this chemical. Soil moisture is essential when chlorate is used as a dry application. The dry form of application is recommended in preference to spraying as it practically eliminates the fire hazard.

#### B. Arsenicals

Sodium arsenate solution has been the standard general contact spray for many years. At the present time arsenic solutions are not generally recommended because they are extremely poisonous to both humans and animals. Other less poisonous sprays have largely supplanted the use of arsenical sprays.

#### C. Borax

Borax may be used on susceptible herbaceous weeds on non-crop land. It will remain in the soil

and affect plants for two years or more. Borax is effective on St. Johnswort *Hypericum perforatum*, Canada thistle, leafy spurge, and other perennial weeds. Applications are usually from 8 to 20 pounds per square rod.

#### D. Ammate

This material is used mainly for elimination of woody shrubs or for killing trees or preventing them from sprouting. Manufacturer's recommendations should be followed.

*EVERY WEEDICIDE MUST BE USED IN THE RIGHT WAY, AT THE RIGHT TIME, AND AT THE RIGHT PLACE IF IT IS TO BE EFFICIENT.*

NOTE: Nearly every state in the Western Weed Control Conference has issued one or more publications on the use of chemicals for spraying. The recommendations in these publications should form the basis of spraying operations in the respective states.

### REPORT OF THE PUBLICATIONS COMMITTEE

C. I. Seely, Chairman

The committee on publications has met and surveyed the situation confronting workers in weed control. We feel that both a long range and interim program is necessary.

Your committee recommends that for a long range program the Western States Weed Control Conference appoint a committee to operate jointly with the other Conferences to work towards the publication of a periodical devoted to weed control. Your present committee feels strongly that such a publication is needed and should be started as soon as possible. It also strongly recommends that no precipitous action be taken so that when such a publication is started it will be a success. It is our belief that an over-all organization of the various Conferences is a prerequisite to such a publication.

Since this program will require considerable time and there is need for immediate action your committee recommends that as an interim program the Bureau of Plant Industry, Soils and Agricultural Engineering of the U.S. Department of Agriculture be requested to compile and issue at frequent intervals a bibliography of current weed literature. This should be distributed to all research and extension workers in weed control and to all regulatory officials in this field.

### REPORT OF THE LEGISLATION COMMITTEE

Bruce J. Thornton, Chairman

President Freed, in appointing the Legislation Committee suggested three objectives as follows:

(1) The development of a uniform weed law as a guide

to member states in the drawing up of new weed laws or revising old ones. (2) The promulgation of a program to bring about legislation providing for adequate funds for weed control work, both state and federal. (3) The accumulation of figures showing economic losses due to weeds to be used in support of requests made in behalf of the weed control program.

As a basis for drawing up a uniform weed law, copies of the weed laws of the states of the Western Weed Control Conference and the North Central Weed Control Conference were requested for each member of the committee. These were not received in time to permit careful study but it was at once evident that the wide diversity in the Administrative and Regulatory organization of the different states practically precluded attempting to write a uniform law on short notice and suggested the need of considerable study to determine whether such a uniform law would have sufficient merit to warrant the time and effort necessary for its proper development.

It was decided, therefore, that a proper approach to the problem would be the listing of those provisions that appear to be essential or highly desirable in a strong and effective weed law. These provisions as determined by the Committee are:

1. Should be strictly Regulatory and in a Regulatory Department or Section.
2. Should provide for unquestioned regulatory authority.
3. Should be state wide in its application.
4. Should provide for setting up weed control districts (a) on a voluntary basis, (b) on a compulsory basis.
5. Should provide for the effective quarantine of a district or portion of a district.
6. Should consist of a Law and Regulations with the Regulations subject to being changed or modified by the established authority within limits prescribed in the Law.
7. Should be enforceable, with any costs involved in the process becoming a lien on the property if payment is refused.
8. Should provide means of raising such funds as may be required to carry out its provisions.
9. Should be correlated with the State Seed Law as to the Noxious weed list and any other provisions common to both laws.
10. The same authority should administrate and enforce the Weed Law and the Seed Law in a state, thus correlating the work, preventing duplication of effort and lessening cost of administration.

It is recognized that there is much to be desired in the above provisions for an ideal weed law and it is hoped that the members of the Conference will give them serious consideration and will feel free to make such comments or suggestions as may be helpful to the Committee in their revision.

With regard to the second objective it was determined that in view of the arrangements now being made in the U. S. Department of Agriculture relative to the weed work there was little that could be recommended by this Conference at this time relative to the Hoeven Bill or other legislation of this type. However workers in individual states should encourage the support of the weed work at the State and County levels.

The Committee feels that the third objective, the accumulation of data as to losses due to weeds, also will have to be carried on a State level. It will be necessary for each State to arrive at these losses by whatever method may be deemed advisable and in turn these losses may be assembled by the Committee. At the same time it will be advisable to determine the gains resulting from weed control efforts. These will be valuable on the basis of individual experiences, on a crop basis or on a district, county, or state basis.

## REPORT OF THE EXECUTIVE COMMITTEE

Walter S. Ball, Chairman

The Executive Committee held two meetings, the first on Sunday, February 1st and the second on February 4.

The first business taken up by the Executive Committee was to consider the joint meeting of the North Central Weed Control Conference and the Western Weed Control Conference. It was decided we should meet jointly, in January or early February, the meeting to be held in Denver; that a committee be appointed by the incoming president to work with the committee of the North Central group. The tentative date would be 1950, if agreeable with the other group.

The next order of business was the time and place of the next meeting of the Western Weed Control Conference, and it was decided that the meeting should be held in Montana-- possibly Bozeman-- the time -- February.

The Executive Committee recommended that one day be given to registration and committee meetings and, further, that the research section make presentation of papers on research, these to be summarized by a committee for the purpose of arriving at general summary and recommendations.

The Chairman of the Resolution Committee forwarded the following recommendations for consideration:

"It appears that research funds can be made available to states under the Marketing and Research Act. Insofar as weed control is concerned, western states have generally failed to take advantage of this opportunity. The executive committee should take any immediate action necessary to obtain money for weed control research in the west".

The Executive Committee took action relative to this recommendation by instructing the incoming

president to appoint a committee to get all available information regarding the Marketing and Research Act.

The Education Committee submitted its report to the Executive Committee for consideration and presentation if they deemed it necessary. Following is the report of the Education Committee by W. W. Robbins, Chairman:

To The Executive Committee  
Western Weed Control Conference:

Your committee on Educational Activity, composed of W. S. Ball, Virgil Freed, D. J. Luebke, C. E. Otis, W. Whitman, Rex Warren and W. W. Robbins wishes to make the following recommendations:

That the Committee, during the coming year, make a study of the various phases of education activity pertaining to weeds in the colleges of agriculture in the United States. This study would include an analysis of on-the-campus instruction and off-the-campus instruction. It would attempt to determine in what institutions special courses in weed control are given, how much time in other courses, such as agronomy, weed instruction is given, and the nature of the subject matter presented.

Also, under the heading of Extension, it would try to determine methods used, character of circulars and other publications which are issued, and the degree of special attention given to the subject by the extension staff.

The Committee would also try to find out what aid the agricultural institutions are giving to the high schools in the states which would facilitate their work on weeds and weed control. Here, we would work through the state 4H Club Leader and the state Smith-Hughes Director.

It is proposed that the Committee prepare a suitable questionnaire which would be sent to every agricultural college in the United States and, when these are turned in, summarize the data and present it at the next Western Weed Control Conference.

## REPORT OF THE RESOLUTIONS COMMITTEE

Chester E. Otis, Chairman

### RESOLUTION NO. 1

*WHEREAS*, the weed control field is fast achieving its rightful position of importance in agriculture, and

*WHEREAS*, most sections of the United States and Canada now have organized regional weed control conferences, and

*WHEREAS*, the need for closer coordination of the activities of those interested in weed control is self evident,

NOW, THEREFORE BE IT RESOLVED that the Western Weed Control Conference, assembled at Sacramento, California, February 2, 3, and 4, 1948, favors and will encourage the establishment of an overall executive council to coordinate the activities of the various weed control conferences.

RESOLUTION NO. 2

WHEREAS, leading agriculturists and others familiar with the facts recognize that weeds present one of the most serious problems facing agriculture today, being responsible for economic losses second only to soil erosion, and

WHEREAS, the control of weeds is essential to the production of high quality and marketable farm crops, and

WHEREAS, all sound weed control programs must be based on research and

WHEREAS, weed control research, in spite of its recently increased tempo, is incommensurate at the federal and state levels with the scope and importance of the problem,

NOW, THEREFORE BE IT RESOLVED that the Western Weed Control Conference, assembled at Sacramento, California, February 2, 3, and 4, 1948, recommends to the Honorable Secretary of Agriculture and to the Chief of the Bureau of Plant Industry, Chemistry, Soils, and Agricultural Engineering, and to the Directors of Agricultural Experiment Stations in the eleven western states that because more weed control research is a great and obvious need, additional funds should be allotted for further federal and state experimental work.

RESOLUTION NO. 3

WHEREAS, papers, articles, stories, etc. are the accepted methods of presenting experimental and new weed control information, and

WHEREAS, weed control embodies the various fields of biological sciences, chemistry, and engineering, and

WHEREAS, according to a survey conducted by the publications committee of the Western Weed Control Conference, there were about 400 weed control articles published in the United States in the year ending November, 1947, and

WHEREAS, these articles appeared in a large number of different publications resulting in much confusion and loss of time and effort on the part of those desiring to keep abreast of new developments,

NOW, THEREFORE BE IT RESOLVED that the Western Weed Control Conference, assembled at Sacramento, California, February 2, 3, and 4, 1948 favors the establishment of a national publication to be used as a medium for transmitting weed control information but

until such a project can be launched on a sound basis recommends that the U.S.D.A. Bureau of Plant Industry, Chemistry, Soils, and Agricultural Engineering issue at frequent intervals a bibliography of weed control literature to be made available to all research and extension workers and state weed control officials.

RESOLUTION NO. 4

WHEREAS, millions of acres of land in the western United States are under the jurisdiction of various federal agencies, and

WHEREAS, much of this land is badly infested with serious weeds which not only affect users of the public lands but pose a threat and often cause losses to owners of nearby deeded land,

NOW, THEREFORE BE IT RESOLVED that the Western Weed Control Conference, assembled at Sacramento, California, February 2, 3, and 4, 1948 suggests to the U. S. Forest Service, Indian Service, Park Service, and Bureau of Land Management that they might well conduct more active weed control programs on lands administered by them.

RESOLUTION NO. 5

WHEREAS, the weed control equipment field day held at Davis, California during the 1948 Western Weed Control Conference was one of the outstanding highlights of the meeting, and

WHEREAS, the Sacramento, California Convention Bureau was most helpful in making the Conference the success that it was,

NOW, THEREFORE BE IT RESOLVED that the Western Weed Control Conference assembled at Sacramento, California, February 2, 3, and 4, 1948 thanks the Agricultural Engineering Division, College of Agriculture, Davis, California for its excellent assistance and cooperation in holding the weed equipment demonstrations. Also, the conference appreciates the assistance rendered by the Sacramento Convention Bureau.

The Secretary is hereby instructed to write appropriate thank you letters to the organizations mentioned in this resolution.

REPORT OF THE NOMINATIONS COMMITTEE

Chester Otis, Chairman

The following nominations were submitted:

Bruce J. Thornton of Colorado . . . . . President

V. A. Cox of Idaho . . . . . Vice-President

Walter S. Ball of California. . . . . Secretary-Treasurer

It was properly moved and seconded that the nominations be approved; the motion carried. The secretary was instructed to cast a unanimous vote for the nominations as approved. It was decided that the 1949 meeting will be held in Bozeman, Montana.

Meeting Adjourned at 4:50 pm.

WALTER S. BALL  
Secretary-Treasurer