Research Bulletin 788 March 1957

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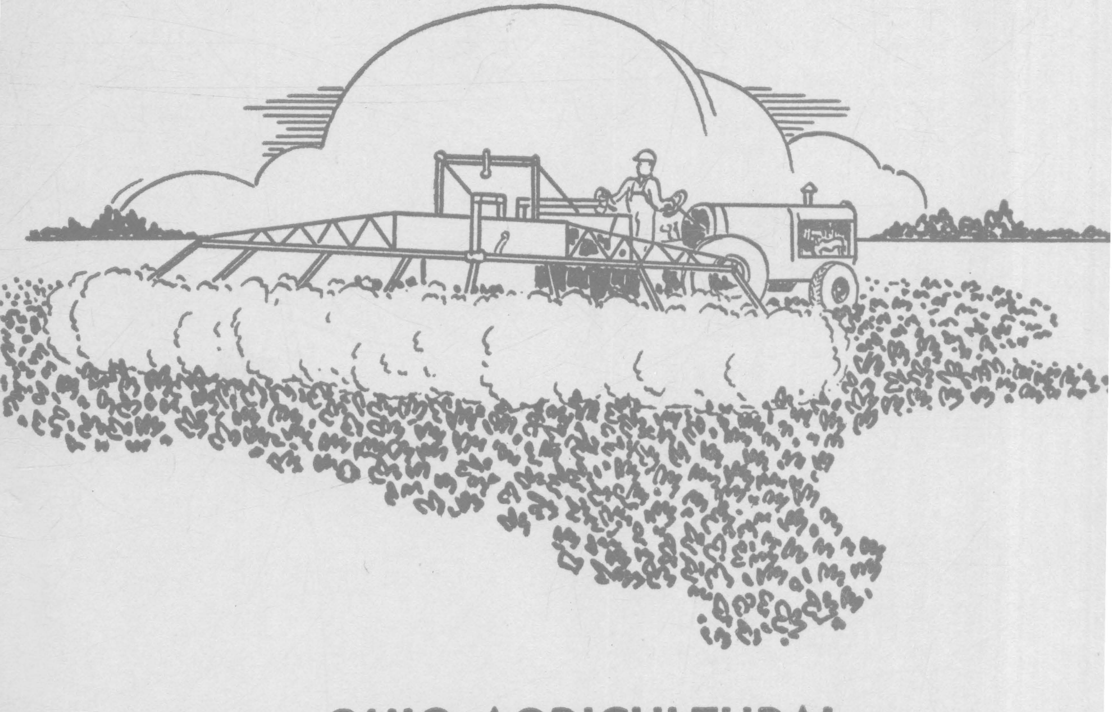

OHIO AGRICULTURAL EXPERIMENT STATION

WOOSTER, OHIO

CONTENTS

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CONTROL OF FOLIAGE DISEASES AND INSECTS OF POTATOES

J. D. WILSON, J. P. SLEESMAN, and FRANK IRONS[1]

INTRODUCTION

Foliage pests most influencing potato production in Ohio are early blight, **Alternaria solani** J. & G., and late blight, **Phytophthora infestans** DeB., among the diseases, and such insects as the potato flea beetle, **Expitrix cucumeris** (Harr.), and the potato leafhopper, **Empoasca fabae** (Harr.). The search for better and less costly control measures for these and other diseases and insects has been responsible for a continuing series of experiments by the authors and other investigators in Ohio for 25 years or more (4, 6, 7, 8, 9, 10, 11, 14, 21, 26, 27, 31, 33, 34, 35, 36, 38, 40). The comparative tests have included a large number of fungicides and insecticides, as well as various mixtures of these materials. Combination fungicide-insecticide formulations have been used in increasing number during the past several years, partly because there has been a rapid increase in new materials in both categories, but more particularly because it has become increasingly evident that the proper use of such formulations to control both diseases and insects is essential to the production of maximum yields of potatoes at the lowest possible cost.

The work reported here on fungicides has been chiefly the concern of the first named author, with that on insecticides being supervised by the second, whereas both have participated in those experiments involving the use of both types of materials. They have been assisted throughout this 13-year period of experimentation by the last-named author, under whose supervision the various types of sprayers and dusters used in the application of the experimental formulations have been designed and constructed in the U. S. Department of Agriculture Engineering Laboratory located at Toledo, Ohio.

Experiments conducted during the late 1930's (6) were concerned largely with various formulations of Bordeaux mixture, but copper-lime and sulfur-lime dust mixtures were also included. One fixed copper

[1]Agricultural Engineer, U. S. Department of Agriculture, Agricultural Research Service, Agricultural Engineering Research Branch, Toledo, Ohio.

(15) was tested in 1936, none in 1937, five in 1938, and these have been followed by two or more during every year since that time. At least one formula of Bordeaux mixture was included for a number of years as a standard fungicide with which all others are compared. This practice has not been followed so consistently during the past few years.

The decade from 1930 to 1939, inclusive, marked the introduction of the fixed coppers as substitutes for Bordeaux mixture on potatoes and various other crops (9, 10, 19, 25). In turn, it was early in the next decade (1940-1949) that a number of organic fungicides, principally the dithiocarbamates, began to appear in experimental trials, and shortly thereafter in commercial use (13, 15, 25, 32). Both of these groups of fungicides (the fixed coppers and then the dithiocarbamates) represented distinct advances in the control of potato diseases, but in 1944 a new insecticide was first used on potatoes in Ohio that probably represented the greatest single advance in potato culture that has ever occurred. This new compound, dichloro-diphenyl-trichloroethane, which is now familiarly known as DDT, gives nearly 100 percent control of the potato leafhopper, which up to the introduction of this material was probably the greatest single deterrent to maximum potato production in Ohio (6, 11). DDT also gave excellent control of the potato flea beetle in these early experiments, which is the second most important insect on Ohio potatoes.

Ferbam (Fermate), a dithiocarbamate, was the first representative of the new group of fungicides commonly spoken of as the "organics" to be included in these tests. It was used in a dust formulation in 1942 and gave the best yield in a group of over 20 treatments (6). Fermate has been followed by an increasing number of synthetic fungicides each year since (15), with several organic fungicides and insecticides (21) now being tested experimentally each year on potatoes and other vegetables in Ohio.

Calcium arsenate was the principal insecticide used in these experimental tests up to and including 1943. A few comparisons were made during the period from 1936 to 1943 (6), that included such materials as nicotine sulfate, rotenone, and pyrethrum. DDT, a synthetic organic insecticide, was first used in this series of tests in 1944 (12), and it has since replaced calcium arsenate as the insecticide with which new fungicides are formulated for comparative testing in the experimental program. However, it now appears that other materials may replace DDT because of its recent failure to satisfactorily control flea beetles. During the past 10 years (11, 12, 16, 23, 27, 29, 30, 33, 34, 36, 41), a considerable number of other synthetic insecticides (See Materials Key) have been compared for the control of potato insects such as flea beetles, leafhoppers, and aphids.

FUNGICIDES, INSECTICIDES, AND ADJUVANTS

Nearly 150 fungicides or fungicide formulations have been used in anywhere from 1 to 50 different experiments during the 13 years covered in this bulletin. Some of those which were used only once have not been heard of since, whereas others such as some of the fixed coppers and of the dithiocarbamates are now used by literally hundreds of growers each year in the control of potato diseases.

Approximately 35 insecticidal compounds, or formulations of the same, have been compared with one or more others in as many as 50 different experiments during the same period. These materials varied all the way from a comparatively simple compound such as calcium arsenate to extremely complex ones such as chlordane and dieldrin.

Many different adhesives, including such commonly occurring materials as wheat and soy flour, clays, bentonite and various kinds of oils, and various surfactants or wetting agenst, chief among which were a number of different types of Triton, have also been compared.

MATERIALS KEY

Fungicides

B-36—An organic mercury derivative
B-59—A rosin amine derivative
B-160—A rosin amine salt
Baycar 4255—A modified dithiocarbamate
Bioquin—Copper 8-quinolinolate
Bioquin 1—Same as Bioquin—80% active
Bioquin 50W—50% Bioquin 1 + 49% Pyrax ABB + 1% Araskap
Bioquin 100—Zinc-8-quinolinolate
Bordeaux mixture—A series of cupric hydroxides
CaBis—Calcium ethylene bis dithiocarbamate
CaCarbamate—Calcium ethylene bis dithiocarbamate
Carbamate, 4-way—A mixture of Cu, Fe, Mn, and Zn salts of sodium dimethyl dithiocarbamate
CBCO (C H CO)—Calumet Brown Cupric Oxide—A cuprous-cupric oxide complex; 75% cuprous and 25% cupric–75% Cu
Chromate A—A copper chromate complex
Chromate B—A copper chromate complex
Chromate 169—4 ZnO . CuO . CrO_3 . 4 H_2O
Chromate 639 C—A relative of Crag Turf Fungicide 531
Chromate 640—Zn 0.4 Cu $(OH)_2$ Cr O_3
Chromate 679—An organic zinc chromate
Cl MBT—5 chloro-2-mercaptobenzothiazole
COC-S—Two parts of basic copper chloride and one part of basic copper sulfate
COC-S, 3-way—A mixture of 3 formulations of COC-S
Cop-O-Zinc—Basic salts of copper and zinc, 42% Cu and 11% Zn
Copper A—Tetra-copper calcium oxychloride

Copper, aerosol—Copper naphthenate solubilized in methylene-chloride
Copper cupferron—Cupric N-nitroso-N-phenylhydro-xylamine-13.2 % Cu
Copper, metallic—A very finely divided metallic copper
Copper phthalate—100 %
Copper-zinc-cupferron—Copper cupferron + zinc-N-nitroso-N-phenylhydroxylamine 70 % active
CP 161—2, 4-Dinitrophenyl thiocyanate
CP 2271—Copper sodium zinc polyphosphate
Crag 658—Copper zinc chromate—15 CuO . 10 ZnO . 6 CrO_3 . 25 H_2O. 30 % Cu and 20 % Zn
Crag 658-B2G—Variant of Crag 658
Crag 658-B3G—Variant of Crag 658
Crag 658-B5G—Variant of Crag 658
Crag 658-B5K4G—Variant of Crag 658
Crag 658-CG—Variant of Crag 658
Crag 698—Minor variant of Crag 658
Crag 829—Minor variant of Crag 658
Crag 829-B5G—Variant of Crag 658
Crag 829-B5K4G—Variant of Crag 658
Crag 1213—A copper-zinc fatty acid complex
Crag 1217—A copper-fatty acid chromate complex—9.1 % solids
Crag 5379—1, 2, 3-Trithio-5, 8-diazocyclononone-4, 9-dithione
Crag 5400—A reaction product of dimethyl dithiocarbamate and sulfur dichloride
Cu MBT—Copper mercaptobenzothiazole
Cuprocide—Yellow cuprous oxide—83 % Cu
Dithane, bonded—Dithane Z-78 bonded with Diluex—50 % active
Dithane D-14—Disodium ethylene bis dithiocarbamate—20 % active
Dithane Z-78—A wettable powder formulation of zinc ethylene bis dithiocarbamate—65 % active
Dithane Z-78, special—A special formulation of Z-78
Dithane Lot 6-799—A standard formulation of Dithane Z-78
Dithane Lot 6-804—As 6-799 but included a special dispersant
Dithane Lot JD-100—As 6-799 but ground in a special mill
Esminel—Nutritional complex of soluble sulfate salts of Cu, Zn, Mn, Fe, Co, and various other essential elements
F 308—Copper nitrodithioacetate
Fac—Ferric dimethyl dithiocarbamate cyclohexylamine (dry)
Fac-S—Ferric dimethyl dithiocarbamate cyclohexylamine (20 % slurry)
Fe (2 & 3) Cl MBT—See Cl MBT
Fermate—Ferric dimethyl dithiocarbamate—70 % active
Fungicide A—Fungicide 1124 (50 %) + Spraycop (40 %)
Fungicide B49—Spraycop (79.5 %) + DDT (20 %)
Fungicide B50—Fungicide 1189 (40 %) + Spraycop (30 %)
Fungicide C—Fungicide 1189 (25 %) + Spraycop (50 %)
Fungicide D—Fungicide 1189—20 %
Fungicide 629—Zinc nitrodithioacetate spray powder—67 %

Fungicide 629-308—33.5% of 629 + 33.5% of 308
Fungicide 1124—2, 4-Dinitrophenyl thiocyanate—50%
Fungicide 1189—Dichlorotetrahydro-4,7-methano-indeneone—50%
Guantal—Di-phenyl guanidine phthalate—100%
He-175—A Dithane D-14 formulation
He-177—Copper ethylene bis dithiocarbamate
Karbam W—A wettable powder formulation of zinc dimethyl dithiocarbamate
Kolofog—Fused sulfur-bentonite complex
Mancupron—An emulgate containing 10% manganese resinate and 15% copper resinate
Manzate—A wettable powder formulation of manganese ethylene bis dithiocarbamate
Manzate A—A variant of Manzate
Me 3905—COC-S + Vancide ZW
Me 3906—COC-S + Vancide F-995
Me 3907—COC-S + TMTD
Mercupron—An emulgate containing 20% copper resinate and 1.0% phenyl mercury salicylate
Methasan—Zinc dimethyl dithiocarbamate
Methasan, bonded—Methasan bonded with Diluex—50% active
Methasan S—A slurry form of Methasan—55% active
Methasan W—A wettable formulation of Methasan—95% active
Mg Carbamate—Magnesium ethylene bis dithiocarbamate
MnEDB—Initialed code for Manzate
N 1286—Zinc ethylene bis (N-2 cyanethyl) dithiocarbamate
N 2230—Di-cyclopenta methylene thiuram disulfide
N 3511—Zinc N-ethyl (N-beta-cyanmethyl) dithiocarbamate
Na Carbamate—Sodium ethylene bis dithiocarbamate
Ni Carbamate—Nickel ethylene bis dithiocarbamate
Nithane—Nickel ethylene bis dithiocarbamate
Ni Cl MBT—Nickel chloro mercaptobenzothiazole
Norblo—A finer particle size preparation of CBCO
Oilcop 110—Special formulation of copper naphthenate
Oilcop 210—Special formulation of copper naphthenate
Orthocide—N-trichloromethylthio tetrahydrophthalimide—50% active
OS-377D—2-heptadecyl-4, 4, 6-trimethyl tetrahydropyrimidine
P 4500—Methasan + Horticultural oil
P 4501—N-1286 + Horticultural oil
P 4502—N-3411 + Horticultural oil
P. D. Paste—Metallic copper in plate-like particles—50% Cu
Parzate—A wettable powder formulation of zinc ethylene bis dithiocarbamate—65% active
Parzate, liquid—Disodium ethylene bis dithiocarbamate
Parzate, special—A special formulation of dry Parzate
Penn A—A copper sludge from a metal processing operation
Penn 492—A halogenated aliphatic acid
Phthalate, 4-way—Cu, Fe, Mn, and Zn phthalate mixture
Phygon-XL—2, 3-dichloro-1, 4-naphthoquinone

Polymer 34.1—A sodium salt of a high mol. wt. cabboxylic polymer
Procop 1—A special COC-S formulation
Procop 2—A special COC-S formulation
Procop 2-A—A special COC-S formulation
Procop 3-A—A special COC-S formulation
Procop 3-B—A special COC-S formulation
Puratized—Phenyl mercury triethanol ammonium lactate
Rimocidin—An antibiotic from **Streptomyces rimosus**
Robertson Fungicide (Rocop)—Metallic copper core plus cuprous oxide coating, the oxide making up 20% of the total weight
Rocop, bonded—Robertson Fungicide bonded with Diluex—50% Cu
SDDC or SDD or Coro SDD—Sodium dimethyl dithiocarbamate—20 and 40% active
SDDC-A—Sodium dimethyl dithiocarbamate-cyclohexyl amine as a liquid—20% active
SEBD—Sodium ethylene bis dithiocarbamate—20% active
Sporcop—Copper naphthenate formulated in oil
Spraycop—A tribasic copper sulfate (53% Cu)
Sterisan—Alkyl dimethyl benzyl ammonium chloride—10% active
Streptomycin—An antibiotic from **Streptomyces grisens**
Sulfur, wettable—Sulfur made wettable by mixing with clay
Tenncop—A basic copper oxysulfate
Tennzinc—A basic zinc oxysulfate
Terramycin—An antibiotic from **Streptomyces rimosus**
Thiolutin—An antibiotic from **Streptomyces albus**
TMTD—Tetra methyl thiuram disulfide
Tracel—A nutritional mixture of several minor elements in sintered form
Tribasic—Cupric trioxysulfate—53% Cu
Tribasic A—A special formulation of Tribasic
Vancide 20S—Monoethanolammonium salt of 2-mercaptobenzothiazole in an organic solvent—40%
Vancide 29EC—Benzyl pyridinium salt of 2-mercaptobenzothiazole in an emulsion concentrate formula—25%
Vancide 51—Sodium salts of dimethyl dithiocarbamic acid and 2-mercaptobenzothiazole—30% active
Vancide 51 ZW—A zinc salt of Vancide 51 prepared as a wettable powder
Vancide 632—A zinc dimethyl dithiocarbamate-zinc mercaptobenzothiazole complex—75% active
Vancide 935—(F 845) (code only)
Vancide 956 W—The iron salt of Vancide 51
Vancide F-995—The manganese salt of Vancide 51
Vancide 1096—Dry Vancide 51 + Vancide 51 ZW
Vancide F-1131—A metal salt of Vancide 51
Velsicol 49-CS-43—Plumbose 1, 4, 5, 6, 7, 7-hexachlorobicyclo-[2, 3, 1]-5-heptone-2, 3-dicarboxylate
Velsicol 50-CS-46—N-ethyl mercuri-1, 4, 5, 6, 7, 7-hexachlorobicyclo-[2, 2, 1]-5-heptone-2, 3-dicarboximide
X P-63—An emulsifiable concentrate containing 15% of OS-377 D

X P-90—A wettable powder of OS-377 D—25% active
X P-94—An emulsifiable concentrate containing 1 lb. per gallon of OS-377 D
Zac—A wettable powder formulation of zinc dimethyl dithiocarbamate-cyclohexylamine complex—25% active
Zac A—Special formulation of Zac
Zac B—Special formulation of Za c
Zac S—A slurry formulation of Zac—40% active
Zac X-5—25/75 Zac/clay combination (dry blended)
Zac X-6—25/75 Zac/clay combination (wet mixed and then dried)
Zerlate—A wettable powder formulation of zinc dimethyl dithiocarbamate—76% active
Zinc phthalate—100%
Zip—(4-1) A carbamate formulation with p.e.p.s.
Zn MBT—Zinc mercaptobenzothiazole
Zn Cl MBT—Zinc chloro mercaptobenzothiazole

Insecticides

Aldrin—1, 2, 3, 4, 10, 10-hexachloro-1, 4, 4a, 5, 8, 8a-hexahydro-1, 4, 5, 8-dimethanonaphthalene
BHC—1, 2, 3, 4, 5, 6-hexachlorocyclohexane
BPR—A mixture of piperonyl butoxide, pyrethrins, and rotenone
Calcium arsenate—Basic calcium arsenate
Chlordane—1, 2, 4, 5, 6, 7, 8, 8-octachloro-4, 7-methano-3a, 4, 7, 7a-tetrahydroindane
Compound 118—Aldrin
Compound 4049—Malathion
CS 645—2-nitro-1, 1-bis (p-chlorophenyl) propane
DDT—2, 2-bis (p-chlorophenyl)-1, 1, 1-trichloroethane
DDTol—DDT emulsifiable concentrate
Deenol—DDT emulsifiable concentrate
Dieldrin—1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4, 5, 8-dimethanonaphthalene
Dilan—1 part 1, 1-bis (p-chlorophenyl)-2-nitropropane and 2 parts 1, 1-bis (p-chlorophenyl)-2-nitrobutane
Dowklor—Chlordane
EM 25-3—Emulsifiable concentrate of 25% DDT + 3% parathion
Endrin—Hexachloroepoxyoctahydro-endo, endo-dimethanonaphthalene
EPN—Ethyl p-nitrophenyl thionobenzene phosphonate
G-23611—1, isopropyl-3 methyl-pyrazolyl-(5)-dimethylcarbamate, 25% active
Gammexane—BHC
Genitol EM 25—Emulsifiable concentrate of DDT (25%)
HETP—Hexaethyl tetraphosphate
Isotox—Gamma isomer of BHC
LB71—Dust concentrate of 13.5% beta beta dithiocyano diethyl ether 86.5%
LB72—Wettable powder of 13.5% beta beta dithiocyano diethyl ether 86.5%

Malathion EM—O, O-dimethyl dithiophosphate of diethyl mercaptosuccinate. An emulsion at 50% active
Malathion WP—A wettable powder formulation at 25% active
Metacide—Methyl parathion + parathion
Methoxychlor—2, 2-bis(p-methoxyphenyl)-1, 1, 1-trichloroethane. A 50% wettable powder
Parathion—O, O-diethyl-O-p-nitrophenyl thiophosphate
Pestox—Octamethyl pyrophosphoramide
Q-137—1, 1-dichloro-2, 2-bis(p-ethylphenyl) ethane
Rhothane—See TDE
Rotenone—Root of Derris ellipitica dried and ground
Systox—Diethoxythiophosphoric acid ester of 2-ethyl mercapto-ethanol
TDE—Dichloro diphenyl dichloroethane
TEPP—Tetraethyl pyrophosphate
Toxaphene—A chlorinated camphene
Z39, DDD—Rhothane

Adjuvants

AS50—(Armour sticker)—Blended natural animal proteins
AS50-R—A modification of AS50
Attaclay—A diluent prepared from Fuller's earth
Bentonite—A volcanic clay
Celite—An infusorial earth
Clays—Various
Diluex—A highly absorbtive form of Fuller's earth
Dresinate—A resin sticker
EMT23 Talc—A flaky talc of specific mesh
Florigel—A special preparation of Fuller's earth
Furofil 100—A combination of modified cellulose lignins and resins
Kaysoy—A specially prepared soybean flour
Methocel—(F 1068)—A water-soluble synthetic gum made from cotton linters—50% active
National Sticker—A sugar derivative (cyclic acetols) dissolved in methanol
Oils—Various mostly light mineral oils—Sun Vis, SEC, Corvus, Vaporol
Omilite—An early formulation of p.e.p.s.
Orthex—A flocculating oil base spreader—90% mineral oil—sticker
Orthol-K—A phytonomic summer oil spray, 83% oil by volume
p.e.p.s.—Polyethylene polysulfide
Polymer 34.1—A sodium salt of polycrylic acid
Tritons—Various
Tween 40—A non-ionic surface agent—a partial ester of fatty acids
Vancide Sticker—A plastic type of emulsion
VL-600—A modified polyvinyl chloride—50% active
Volck—A highly refined phytonomic summer spray oil
Z-1—A highly colloidal adhesive

For several years the comparative tests were made chiefly on the State Muck Farm at McGuffey (6). In 1942 a series of experiments was started at Marietta on the control of the potato flea beetle (7), and in 1943 another series was begun at Wooster on disease and insect control. For a number of years since 1943, identical tests were conducted at Wooster, Marietta, and McGuffey. Still more recently the tests at McGuffey have been replaced by others conducted on a new Muck Experiment Station near Willard, Ohio.

This procedure of testing various materials at three locations has been of special value, since it has made possible a comparison between various treatments under three different combinations of soil and climatic conditions, and because of these environmental differences, the disease and insect complexes also have been different. Flea beetles are usually plentiful at all three locations, but are especially numerous at Marietta. Leafhoppers were a major factor in decreasing potato production in all three areas until DDT came into general use.

Early blight consistently has been present on potatoes at Wooster for many years, and it usually appears at Marietta, McGuffey, and Willard. Late blight was present nearly every year at McGuffey from 1932 until 1948, but did not appear every year at either Wooster or Marietta during the same period. Neither has it caused appreciable loss at Willard since 1950.

WEATHER DATA

Weather data of various kinds, but particularly temperature and rainfall records, were obtained each year at Marietta, Wooster, McGuffey and/or Willard. Since the publication of all of these data in an article of this kind would not be practical, it was decided to publish only the Wooster data, and then only mean and mean average temperatures and total and average rainfall (together with departures). Well over half of the experimental work was done at Wooster, and the weather there is indicative in a very general way of the weather for other parts of the state for the growing season as a unit or whole.

The data for the growing season (April 1 through September 30) at Wooster are given below for the years 1943-1955, inclusive.

Temperature and Rainfall Data at Wooster, Ohio, for the Months of April Through September, 1943 to 1955, Inclusive

Year and month	Temperature			Rainfall		
	Mean	Mean average	Departure	Total	Average	Departure
1943						
April	41.0	48.3	—7.3	2.28	3.07	—0.79
May	57.8	58.7	—0.9	6.27	3.85	+2.42
June	71.9	67.8	+4.1	0.88	4.09	—3.21
July	71.3	71.8	—0.5	5.72	3.93	+1.79
August	67.8	69.7	—1.9	3.44	3.57	—0.13
September	59.9	63.8	—3.9	1.78	3.09	—1.31
Average	61.6	63.3	—1.7	3.39	3.60	—0.21
1944						
April	45.8	48.2	—2.4	4.33	3.07	+1.26
May	64.9	58.8	+6.1	6.07	3.87	+2.20
June	70.6	67.8	+2.8	3.53	4.11	—0.58
July	70.7	71.8	—1.1	1.24	3.94	—2.70
August	70.3	69.8	+0.5	3.38	3.57	—0.19
September	60.3	63.7	—3.4	1.13	3.09	—1.96
Average	63.7	63.3	+0.4	3.28	3.61	—0.33
1945						
April	52.2	48.3	+3.9	3.33	3.08	+0.25
May	53.4	58.7	—5.3	4.81	3.86	+0.95
June	66.1	67.8	—1.7	4.79	4.11	+0.68
July	71.7	71.8	—0.1	2.92	3.93	—1.01
August	71.9	69.8	+2.1	1.75	3.56	—1.81
September	67.5	63.8	+3.7	5.58	3.09	+2.49
Average	63.8	63.3	+0.5	3.86	3.60	+0.26
1946						
April	48.1	48.3	—0.2	0.74	3.08	—2.34
May	58.1	58.7	—0.6	7.16	3.84	+3.32
June	66.8	67.8	—1.0	7.06	4.06	+3.00
July	71.4	71.8	—0.4	2.97	3.94	—0.97
August	65.4	69.7	—4.3	1.26	3.55	—2.29
September	64.9	63.8	+1.1	1.15	3.09	—1.94
Average	62.4	63.3	—0.9	3.39	3.59	—0.20
1947						
April	48.0	48.3	—0.3	4.78	3.07	+1.71
May	55.8	58.7	—2.9	5.74	3.87	+1.87
June	67.1	67.8	—0.7	10.04	4.09	+5.95
July	69.3	71.8	—2.5	3.65	3.91	—0.26
August	76.2	69.8	+6.4	7.06	3.57	+3.49
September	64.3	63.8	+0.5	3.73	3.11	+0.62
Average	63.4	63.3	+0.1	5.83	3.60	+2.23
1948						
April	51.6	48.4	+3.2	4.05	3.07	+0.98
May	55.4	58.6	—3.2	3.55	3.87	—0.32
June	67.0	67.8	—0.8	5.45	4.09	+1.36
July	72.0	71.8	+0.2	1.45	3.91	—2.46
August	69.7	69.8	—0.1	2.10	3.57	—1.47
September	64.7	63.8	+0.9	2.19	3.11	—0.92
Average	63.4	63.3	+0.1	3.13	3.60	—0.47

1949						
April	45.9	48.4	—2.5	2.79	3.07	—0.28
May	60.4	58.6	+1.8	2.59	3.85	—1.26
June	72.2	67.9	+4.3	4.28	4.09	+0.19
July	76.2	71.9	+4.3	4.90	3.93	+0.97
August	71.5	70.1	+1.4	3.40	3.57	—0.17
September	58.6	64.1	—5.5	2.08	3.09	—1.01
Average	64.1	63.5	+0.6	3.34	3.60	—0.26
1950						
April	42.7	48.2	—5.5	3.34	3.07	+0.27
May	59.6	58.6	+1.0	5.05	3.87	+1.18
June	66.3	67.9	—1.6	5.28	4.11	+1.17
July	69.7	71.9	—2.2	4.31	3.94	+0.37
August	68.1	70.0	—1.9	3.67	3.57	+0.10
September	62.1	64.0	—1.9	1.58	3.09	—1.51
Average	61.4	63.4	—2.0	3.87	3.61	+0.26
1951						
April	46.2	48.1	—1.9	3.67	3.08	+0.59
May	59.8	58.7	+1.1	3.15	3.86	—0.71
June	67.7	67.9	—0.2	3.90	4.11	—0.21
July	71.5	71.9	—0.4	3.55	3.93	—0.38
August	69.3	70.0	—0.7	2.61	3.56	—0;95
September	61.0	64.0	—3.0	3.24	3.09	+0.15
Average	62.5	63.4	—0.9	3.35	3.60	—0.25
1952						
April	49.4	48.1	+1.3	3.09	3.08	+0.01
May	56.7	58.6	—1.9	2.70	3.84	—1.14
June	71.5	67.9	+3.6	1.02	4.06	—3.04
July	74.1	71.9	+2.2	4.73	3.94	+0.79
August	70.1	70.0	+0.1	3.10	3.55	—0.45
September	62.1	64.0	—1.9	2.93	3.09	—0.16
Average	63.9	63.4	+0.5	2.92	3.59	—0.67
1953						
April	44.9	48.1	—3.2	2.69	3.07	—0.38
May	60.9	58.7	+2.2	4.74	3.85	+0.89
June	68.6	67.9	+0.7	1.87	4.03	—2.16
July	71.0	71.9	—0.9	3.36	3.93	—0.57
August	70.0	70.0	0.0	1.43	3.52	—2.09
September	62.8	64.0	—1.2	1.21	3.06	—1.85
Average	63.0	63.4	—0.4	2.55	3.57	—1.02
1954						
April	53.1	48.2	+4.9	5.30	3.10	+2.20
May	53.5	58.6	—5.1	1.17	3.81	—2.64
June	68.9	67.9	+1.0	1.74	4.00	—2.26
July	69.8	71.9	—2.1	1.57	3.89	—2.32
August	69.4	70.0	—0.6	2.40	3.50	—1.10
September	65.1	64.0	+1.1	1.88	3.04	—1.16
Average	63.3	63.4	—0.1	2.34	3.54	—1.20
1955						
April	53.2	48.2	+5.0	2.53	3.09	—0.56
May	60.0	58.6	+1.4	2.18	3.79	—1.61
June	63.9	67.8	—3.9	2.57	3.98	—1.41
July	74.8	71.9	+2.9	6.18	3.92	+2.26
August	73.0	70.1	+2.9	3.48	3.50	—0.02
September	63.8	64.0	—0.2	2.85	3.04	—0.19
Average	64.7	63.4	+1.3	3.29	3.55	—0.26

There were wet or dry and cold or warm periods of varying length each season, as one would expect, and some of these were peculiarly effective in regulating the extent to which specific diseases developed on specific crops. In 1943, a cold, dry April and a warm, dry June were the principal features of an otherwise fairly normal summer. May of 1944 was very warm and somewhat wet, whereas September was cold and dry. In 1945, May was cold and rather wet, whereas September was warm and wet.

Late blight was severe over much of Ohio in 1946 during a period of slightly below normal temperatures, especially during August when late blight became rather severe. The month, however, was somewhat drier than average. June of 1947 was very wet, as was August, and the latter was also very warm. Some late blight appeared in 1947, but early blight was much more important as a factor in plant defoliation. The weather was quite average in 1948 with a rather wet June and a drier than usual July. Mid-summer of 1949 was somewhat warmer than normal at Wooster, with rainfall close to the average. Some late blight was present at different points in the state.

Late blight became very severe in tomatoes and potatoes at Wooster in 1950. The summer was somewhat cooler than the long-time average with a comparatively wet May and June and a nearly normal July and August. A series of cool nights and heavy rains in July and August touched off a near epidemic and unsprayed tomatoes and potatoes were virtually defoliated by mid-September.

Late blight did not appear again in any quantity at Wooster until 1955. In the meantime early blight continued in an average degree of severity nearly every year. The summer of 1951 was near the normal in temperature and rainfall with a slight deficiency in both. Neither was there anything very unusual about 1952 or 1953. So far as mean averages were concerned, April of 1954 was warm and wet, but the rest of the summer was comparatively cool and dry, except for several cold nights.

The growing season of 1955 was the warmest for some time, but rainfall was plentiful in many areas of the state; in fact, the average temperature was the highest of any of the 13 years for which the data are given. There were many hot nights in July and August and July experienced over 6 inches of rain, or an excess of 2 inches. In spite of this kind of weather late blight appeared in potatoes in the vicinity of Wooster and caused considerable defoliation in some fields. Early blight was of medium severity, becoming quite active late in the season.

METHODS

The usual methods for the field testing of new materials have been followed in these experiments (3, 37). First, a suitable site with the proper degree of fertility, good drainage, and of the right size and shape for plot arrangement and replication was selected. Then a variety that fitted the necessary planting and harvesting dates was chosen. Irish Cobblers have been used for early planting, and chiefly Katahdins for later harvesting.

Two-row plots in 4, 5, or 6 replicates have been used in most instances. The paired rows were spaced 32 inches apart, and the space between the pairs (where the sprayer wheels travel) has been varied between 36 and 40 inches. In a few experiments single-row plots, with the rows spaced up to 44 inches apart, have been used. The spray and/or dust applications (5, 20) were made for several years with self-propelled units (Figures 1 and 2) designed and built about 1940 by the U. S. Department of Agriculture Engineering Laboratory at Toledo, Ohio, under the direction of the last named author.

Then for a number of years independently powered sprayers and dusters mounted on the rear of 4-wheeled tractors were used as applicators. Still more recently the above mentioned Engineering Laboratory developed a sprayer assembly in which the pump is driven by power transmitted from the front end of the motor of the tractor on which the sprayer is mounted (Figure 3), and this type of unit is still being used for spraying experimental plots. In addition, work has been done with large commercial hydraulic sprayers (Figure 4) and air-blast applicators (46) of the type shown in Figure 5. Also, some spray and dust experiments have been conducted with experimental airplanes developed by the Agriculture Engineering Department of the Ohio State University. One of the most recent of these is shown in Figure 6 applying a fungicide-insecticide formulation to potatoes as a spray at the rate of 10 gallons per acre (45).

It has been rather general practice to combine the work on fungicide and insecticide formulations, since it is seldom practical, even in grower practice, to make separate applications for disease and insect control. As a result the authors have rather consistently tested several insecticides with some one of the fungicides being used in a given experiment, and then in turn have used a single insecticide with all of the different fungicides being investigated in any single experiment.

Fig. 1.—Self-propelled sprayer, equipped with speedometer. Capable of very accurate calibration of application rates.

Fig. 2.—Self-propelled duster. Duster hopper equipped with an aerating device, and a special quadrant scale making accurate calibration of flow rates possible.

Fig. 3.—Tractor-mounted sprayer unit driven by power take-off on front of motor—also equipped with low-pressure by-pass for application of concentrates.

Fig. 4.—Large capacity, high-pressure, hydraulic sprayer.

Fig. 5.—Large capacity, air-blast sprayer for low-gallonage spraying of row crops.

Fig. 6.—Airplane equipped with spray boom for low-gallonage applications.

Most of the applications have been made on a 10-day schedule rather than the weekly treatments more commonly used by the growers, since with the longer interval the materials being compared may show somewhat greater differences than otherwise, especially if there is a tendency for adhesion to be poor, or if the pesticides are subject to partial decomposition within a period of 5 to 10 days.

Estimates of foliage condition, made in terms of the percentage of defoliation, were usually spaced at 10-day intervals, beginning when about half of the leaves on the untreated check plants were dead. In addition, the initial appearance and later development of specific diseases was also noted, and frequently attempts were made to correlate this with the weather. Hygrothermograph records have been made in various instances to aid in making these comparisons between weather factors and disease and insect incidence.

Leafhopper populations were determined by counting the nymphs on 10 leaves selected at random from each plot. Since the nymphs seldom leave the plant, they can be counted readily upon an individual leaf, whereas the adult leafhoppers are very active and move freely from plant to plant. Thus, the nymphal count was considered to be the better index of relative populations. Aphid counts were made on similarly collected samples (6, 8, 12, 17, 33).

Flea beetle populations were not determined by actual count of the insects. The number of feeding punctures in a unit area of leaf surface was considered to be a more reliable index to the size of the adult populations. A sample of 20 leaflets was selected at random from each plot, and the number of feeding punctures was counted either in the entire leaflet, or in a circular area 1.5 centimeters in diameter taken from that portion of the leaflet where injury was heaviest (6, 8, 11, 13, 17).

RESULTS

Potatoes were sprayed and dusted with various materials at Wooster and McGuffey in 1942. Most of the data obtained in those experiments were published previously (6), but since Fermate as a representative of the dithiocarbamates was used for the first time on potatoes in Ohio during that year, the results obtained with this material and a few others are included in Table 1 of this bulletin. All of the fungicidal formulations listed in Table 1 gave a significant increase in yield and a decrease in leafhoppers when compared with the untreated check. Fermate (ferbam) gave a significant increase in yield over all of the copper-containing treatments being applied as dusts. It also held defoliation in check to a greater degree than any of the copper compounds, including Bordeaux mixture. As will be shown later, this apparent superiority of Fermate over the fixed coppers was not maintained in later experiments (15). The leaves on the plants treated with Fermate in this experiment turned a bright yellow rather than brown at maturity, apparently because of some unusual chemical effect on certain pigments in the leaves.

1943

In 1943 (7, 8), a special study was made of the comparative effectiveness of various fungicide-insecticide formulations when they were applied at differently timed intervals. The materials used and some of the results obtained at Wooster are shown in Table 2. All of the formulations gave a significant increase in yield over that obtained from the untreated check plots. The leafhopper populations were greatly reduced by all treatments (1) with the exception of Fermate, but none gave more than an average degree of control of flea beetles. An 8-12-100 Bordeaux mixture applied every 5 days gave the best flea beetle control.

Defoliation, most of which was caused by early blight, was controlled most effectively by the use of an extra amount of copper (treatments 2 and 9), and by the addition of calcium arsenate to Bordeaux or COC-S (treatments 5 and 12). Although the use of calcium arsenate did not in itself increase the amount of copper on the foliage, or improve adhesion, its use did aid in disease control in some undetermined manner in this experiment. It added comparatively little to the control of flea beetles and leafhoppers (7).

The use of Volck and/or Orthex added nothing to the effectiveness of Bordeaux mixture, and this was also true of Orthex and/or bentonite when added to COC-S. The use of bentonite with COC-S improved copper adhesion greatly but the mixture was somewhat injurious to the potato foliage, and as a result the yield was reduced. Neither did lime or sulfur add anything to the performance of COC-S. This compound applied as a dust was less effective in disease and insect control than when used as a spray, possibly because of poor adhesion of the copper fraction in the dust formulations.

Fermate, which gave excellent results when used as a dust in 1942 (Table 1), did very poorly in both disease and insect control in 1943 when it was applied as a spray. No obvious explanation is available for this reversal in performance, except that it is possible that considerably more of the active ingredient may have been added to the foliage when it was applied with a hand duster in 1942.

When the amount of lime used in the preparation of Bordeaux mixture was varied, there was little difference between the effectiveness of an 8-12-100 and an 8-16-100, but the 8-4-100 formulation was definitely inferior in all categories, including copper adhesion (Table 2).

Reducing the interval between spray applications from 10 to 5 days (8), with no increase in the amount of copper applied (treatments 1 and 8 at 10 days and 3 and 10 at 5 days in Table 2), had no effect on yield with either Bordeaux or COC-S, although the amount of copper present on the foliage after weathering was increased slightly. Neither was disease or insect control appreciably improved. When the formulas of treatments 1 and 8 were left unchanged, but applied at 5-day intervals (treatments 2 and 9), which was equivalent to applying twice the amount of copper, yields were increased slightly with COC-S and significantly with Bordeaux mixture. Both disease and insect control were also improved, probably because of an increase in the magnitude of the weathered copper deposits.

Another series of tests was conducted at Wooster in which Bordeaux and Copper A were applied to potatoes at 10-day, weekly, and semi-weekly intervals (2). These application intervals represented 7, 9, and 18 sprays, respectively, during the season. Some of the data relative to this experiment are given in Table 3.

A significant increase in yield was obtained in most instances when the number of sprays for the season was increased from 7 to 9 and then in turn to 18. The foliage remained green much longer on the plots sprayed 18 times than on those that received only 7 applications. Flea beetle damage was also decreased as the spray interval was shortened. The use of calcium arsenate decreased the number of beetle feeding punctures somewhat and increased the yield for each spray interval and with both Bordeaux mixture and Copper A.

All of the treatments used at Wooster in 1943, and which are listed in Table 2, also were used at McGuffey. In addition, one spray material listed under the code name of He-175, which was the forerunner of Dithane D-14 (nabam), was used for the first time in Ohio. Six additional dust formulations were also applied, as indicated in Table 4. A difference in yield of 75 bushels per acre was required for significance, and as a result only a few of the treatments were significantly better or poorer than most of the others. The yields of all treated plots were significantly better than the untreated check, with the exception of COC-S plus bentonite (treatment 13). The bentonite was injurious to the potato foliage in this instance. He-175 gave the best yields in this experiment, but could not be rated significantly better than about half of the remaining treatments. Fermate gave better results as a dust than as a spray, but in spite of this its performance did not measure up to that of 1942, when it was responsible for the highest yield among a group of 23 materials.

There was no significant difference in flea beetle control by the various treatments listed in Table 4, but the untreated plants were not severely damaged by this insect. No data on leafhopper infestation were obtained. Early blight was the only foliage disease of any consequence, and the variations in its control, as indicated by percentage of foliage dead on the differently treated plots (last column of Table 4), were not as great as usual in this type of experiment.

Doubling the amount of copper applied by halving the interval had little or no effect on disease or insect control, nor on yield. Halving both the interval and the amount of active ingredients in the Bordeaux and COC-S formulas decreased their effectiveness in all categories. Differences in the performance of Bordeaux mixture prepared with different amounts of lime were not significant. The addition of Orthex to COC-S definitely decreased fungicidal efficiency in this experiment, and it did not improve the performance of Bordeaux mixture. Neither lime nor sulfur justified their use with COC-S. Calcium arsenate, contrary to the data obtained in both experiments at Wooster, failed to improve the performance of either Bordeaux or COC-S,. Bentonite again caused a marked decrease in yield when used with COC-S, possibly because of an increase in the amount of foliage injury over that caused by COC-S only.

Dusts applied at the rate of 70 to 75 pounds per acre (resulting in an excessive use of the fungicidal ingredient) gave as good or better results than those obtained by applying 150 to 175 gallons of spray material per acre. This was true for both Fermate and COC-S. The addition of sulfur to the fungicide-talc formula did not appreciably alter the performance of COC-S, Tribasic, or Cuprocide.

1944

Potatoes were again sprayed and dusted in experimental plots at Wooster, Marietta, and McGuffey in 1944 (12). The data relative to one of the Wooster tests are given in Table 5. The season was comparatively dry at Wooster, the rainfall being only 9.28 inches from June 1 to October 1, or a deficiency of 5.4 inches during that period, and the yields were low. The differences between the good and poor treatments were small, since there was not enough soil moisture to allow even well sprayed plants to produce more or larger tubers, even though the necessary leaf area was present.

All of the treated plots yielded significantly more than the untreated check. The increase necessary for significance had the low value of 11 bushels per acre, but as mentioned above, all yields were smaller than usual. DDT was used in only one spray formula, where it gave the highest yield in the whole group of 19 treatments. It was significantly better than all but two of the eighteen used. Methasan (zinc dimethyl dithiocarbamate, or ziram) plus calcium arsenate was one of these, and Bordeaux mixture plus calcium arsenate applied every 5 days was the other. This use of ziram marked one of the first times this organic zinc compound was used on potatoes. It has been tested in succeeding years under the trade name of Zerlate. Puratized (a phenyl mercury lactate) was also included in this experiment but proved to be too injurious to the potato foliage for further use. Fermate again did rather poorly, and Dithane (He-175), which had done so well in 1943 failed to repeat its previous performance, apparently due to faulty formulation by the manufacturer.

There was little choice, in terms of yield, between several different Bordeaux formulas (12), used with or without calcium arsenate, and with 5- or 10-day application intervals. COC-S did give a significant increase in yield when the 4-100 formula was applied every 5 days in contrast with a 10-day schedule. Yields were not increased appreciably with an increase in the application rate of a dust prepared with COC-S. This again was due primarily to the retarding effect on growth of an extremely low soil moisture content (21, 26).

There was some variation in the degree of flea beetle control with the various treatments. The addition of calcium arsenate to an 8-8-100 Bordeaux gave a worthwhile reduction in feeding punctures, as did shortening the application interval from 10 to 5 days. DDT gave a similar reduction when applied with COC-S as a dust (treatment 16). Flea beetle damage was heavy on plants treated with COC-S and with Dithane (treatments 6 and 10), respectively, and it was greater on dusted than on sprayed plots. LB72 (lethane) failed to appreciably reduce feeding by this insect.

Most of the treatments used gave a marked reduction in the population of leafhopper nymphs, with the possible exception of those prepared with the organic fungicides. Any increase in the amount of copper applied (which is somewhat toxic to leafhoppers) decreased the number of leafhoppers (1). The use of calcium arsenate had little or no influence in reducing the leafhopper populations. Elimination of this insect was complete with DDT (treatment 16).

The control of defoliation (last column of Table 5) was accomplished best with the mixture of COC-S and DDT. (COC-S applied as a dust was about as effective as when used as a spray.) The plots treated with Bordeaux were slightly greener toward the end of the season than those sprayed with COC-S. An increase in the amount of copper applied improved the foliage on both the Bordeaux and COC-S plots (treatments 4 and 7). Methasan (ziram) gave fair control of defoliation, but Dithane (zineb) did poorly in this experiment. Fermate (ferbam) was intermediate in performance.

A series of experiments conducted at Wooster in 1944 continued the study of the influence of the timing interval on disease and insect control (6, 7, 8) and also furnished a further comparison of a number of the insecticides and fungicides listed in Table 5. The data relative to this experiment are given in Table 6. DDT was used in three of the treatments listed in Table 6 and the yields of the plots which received this material were significantly above those obtained with calcium arsenate, or with two new lethane formulations listed as LB71 and LB72. It is worthy of note that DDT used without a fungicide gave a higher yield than any of the fungicide-insecticide combinations which did not contain it. These high yields were due largely to the excellent control of leafhoppers and flea beetles obtained with the DDT (11).

The addition of calcium arsenate to Bordeaux mixture and to Copper A gave increases in yield over the treatments that did not include it, but these increases were not significant. He-175 (Dithane) again gave comparatively poor results, but it was improved by the addition of calcium arsenate. The addition of calcium arsenate to LB71 also resulted in an increase in yield over LB71 used alone. Shortening the spray interval from 9 to 6, and then to 3 days, resulted in a yield increase with both the Copper A and Bordeaux formulations. Shortening the interval between applications also improved the control of leafhoppers and of flea beetles. The addition of calcium arsenate to these fungicides improved insect control. Plots treated with dust formulations did not yield quite as high as those which received the corresponding materials applied as sprays.

Flea beetle punctures were most numerous in the dusted plots and in those treated with He-175 used with and without LB71. LB71 and LB72 also failed to give satisfactory control of flea beetles when used alone. Leafhopper control was comparatively poor with most of the formulations listed below DDT-50W (treatment 15) in Table 6. Flea beetle feeding was consistently low wherever the foliage was kept well covered by applying the various materials at 3-day intervals (treatments 1, 4, 7, and 10). The average amount of flea beetle damage increased with a lengthening of the application interval to 6, and to 9 days.

Forty-seven treatments were included in an experiment on potatoes at McGuffey in 1944. Variations in these made possible a further study of the application interval, the effect of calcium arsenate, DDT, and the lethane formulations on insect populations. Still other treatments provided a comparison of various fungicides for disease control, the influence on yield of nutritional elements applied to the foliage, and the relative effectiveness of dust and spray formulations. The data relative to this series of treatments are given in Table 7.

All of the treatments used gave significant increases in yield over the untreated check with the exception of three of those that contained Fermate. This material used alone was little better than the check in this experiment, even when it was applied every 5 days. Adding calcium arsenate to Fermate increased the yield somewhat. The addition of zinc sulfate and hydrated lime was responsible for a considerable increase, and the mixture of Fermate and DDT nearly doubled the yield over Fermate used alone. DDT caused marked increases in yield by all of the treatments in which it was used.

The use of LB72 brought about a considerable increase in yield over the check plots. The addition of calcium arsenate to COC-S was comparatively ineffective, except that it did reduce the damage from flea beetles to some extent, and a specially formulated calcium arsenate under the trade name of Niakil was only slightly more effective. The addition of $ZnSO_4$ and hydrated lime to COC-S contributed little to the effectiveness of this copper fungicide. The use of DDT with COC-S (treatment 26) increased the yield significantly over that obtained with COC-S alone, but the presence of the fungicide resulted in no increase in yield over DDT alone (treatment 25), even though the foliage condition at the end of the season was better and the flea beetle populations were lower. Shortening the application interval did not appreciably increase the yields obtained in this experiment with either COC-S or Bordeaux mixture.

Dithane gave results comparable with most of the other fungicides. It was not improved appreciably by the addition of zinc sulfate plus lime, or by the use of LB72. The addition of calcium arsenate to Dithane seemed to decrease its fungicidal effectiveness, indicating that perhaps the two were not strictly compatible.

Puratized again caused some injury and failed to increase the yield sufficiently to justify its further use on potatoes. Methasan (ziram) gave outstanding control of early blight, and as a result it gave the highest yield of any fungicide used with calcium arsenate in this test. Copper A used alone gave only mediocre results, and this was also true of a finely ground metallic copper (treatment 31), although both gave a significant increase in yield over the untreated check plots. Treatments 41 to 45, inclusive, in Table 7 represent a special test on nutritional sprays.

What little increase in yield that occurred with Bordeaux when the interval was shortened was only apparent when the concentration of the copper was not halved. The plots treated every 3 days with Bordeaux actually yielded less than those on the 10-day schedule, apparently because of foliage injury (2) by the excess of material on the leaves. The addition of DDT to an 8-8-100 Bordeaux gave a significant increase in yield.

When a dust mixture consisting of COC-S plus calcium arsenate and talc was used at 40, 60, and 80 pounds per acre, there was a significant increase in yield as the amount applied was stepped up from 40 to 60 pounds; and, although a further increase to 80 pounds gave a still better yield, the difference between this and the 60-pound application was not large enough to be significant. Fermate again did much better as a dust than as a spray. An LB71 dust mixture gave an increase in yield over the untreated plants.

In an examination of the degree of flea beetle control obtained in these experiments it is evident that there is no substitute for such a frequency of application that the new growth is kept constantly covered. Bordeaux mixture applied three times weekly reduced feeding to a much greater extent than any other treatment. Also, it seems likely that the presence of a large deposit of insoluble material on the foliage checks feeding by its repellent action. All Bordeaux formulas gave fair control of flea beetles. DDT was outstandingly effective against flea beetles, and feeding was reduced by approximately 75 percent wherever it was used.

However, it was in the control of leafhoppers that DDT was most strikingly effective. No nymphs were found on the foliage of plants treated with this material (treatments 16, 25, 26, and 46 in Table 7). It was also observed that these insects were much less numerous on plots adjacent to those treated with DDT (treatment 7). For instance, the average number of nymphs per 100 leaves on plots treated with DDT, those adjacent on each side, once removed, and twice removed, were 0, 86, 306, and 384, respectively. The distance over which the drift of DDT was influential in reducing the leafhopper population was about 8 feet, but it was comparatively ineffective at 11 feet (13). The effect of drift of DDT was not so marked on the control of flea beetles, since the corresponding values in terms of feeding punctures per 10-leaf sample were 38.5, 86.8, 88.4, and 86.4, respectively.

Fermate used alone or with calcium arsenate was ineffective in controlling leafhoppers, as was Tracel (a comparatively insoluble nutritional complex). The leafhopper populations were also high with metallic copper and with Puratized. The "LB" compounds, which contained lethane, were quite effective in reducing leafhopper populations and might have been given more careful consideration for this purpose if DDT had not become available at this time.

The control of defoliation, most of which was caused by early blight and a small amount of late blight, was best accomplished by Bordeaux mixture, COC-S at 5-day intervals, or when used with DDT (24, 25), Fermate with DDT or with zinc sulfate plus lime, and Methasan plus calcium arsenate.

The beneficial effect of adding $ZnSO_4$ and hydrated lime to Fermate (treatments 13 and 17) was interesting since later experience has shown that several fungicides which contain zinc, such as ziram (Zerlate), zineb and nabam (Parzate and Dithane), and copper zinc chromate (Crag 658), are all effective in the control of early blight of potato (15, 27, 28, 30, 32).

A fourth experiment on spraying and dusting potatoes was located at Marietta in 1944. The data are given in Table 8. The plots were located in an area where there was a considerable variation in soil conditions (37) and as a result the yield difference between treatments that was necessary for significance was comparatively large. Three of the treatments used contained DDT and all three of these gave excellent yields (treatments 2, 7, and 8 in Table 8). Fermate gave a significant yield increase over DDT used alone, and COC-S failed to be significant by a narraw margin. These three treatments gave the best control of flea beetle damage and of leafhoppers.

The addition of calcium arsenate to the various fungicides gave only a slight reduction in flea beetle feeding. The "LB" compounds were only slightly more effective and fell far below DDT in this respect. Frequent inspections of the potato plants indicated that DDT kept the flea beetles from feeding on the leaves for a period of about 6 days after it was applied, whereas other materials such as Bordeaux mixture, with or without the addition of calcium arsenate, had lost their ability to check the feeding by the fourth day. DDT also gave excellent control of leafhoppers in this experiment. LB72 and calcium arsenate were much less effective.

Aphids became quite numerous on some of the plots during the latter part of the growing season. They were least numerous on the plots treated with DDT and most plentiful on those treated with calcium arsenate. A build-up of aphid populations on plants treated with calcium aresnate has been noted frequently, and DDT also fails to give effective aphid control in most instances. The plants in the untreated check plots were the first to be defoliated by the attack of diseases and insects. These were followed in an increasing order of longevity by those treated with LB72, copper used alone, He-175, copper-lime dust, Bordeaux mixture, DDT used alone, and finally by Fermate plus DDT.

1945

In 1945, potato experiments located at Marietta, Wooster, and McGuffey were treated with various fungicides, the list of which had begun to include several of those now in common use (16, 17, 18). The comparisons between DDT and calcium arsenate were continued, and DDT was used in various formulations, and at several different concentrations, in an effort to determine the minimum quantity of this unusually effective insecticide that might furnish effective control of potato insects. The data relative to these 1945 experiments are given in Tables 9 to 17, inclusive.

The comparative effectiveness of DDT and calcium arsenate when used with various fungicides, and comparisons between these fungicidal materials are shown in the data of Table 9 relative to an experiment conducted at Wooster in 1945. This series of treatments also included some of a nutritional nature, various formulations of Dithane, and spray and dust applications of DDT. Early blight was the only foliage disease of any consequence, but at least three insects were present to some extent. Flea beetle damage was comparatively mild, aphids were severe on all plots that were treated with calcium arsenate, and leafhoppers were plentiful on most of the plants that were not protected with DDT. There was a marked difference in the number of flower clusters on the differently treated plots (18) and data relative to these also are included in Table 9.

Bordeaux mixture, which is somewhat injurious to many of the plants to which it has been applied for the control of foliage diseases (2, 4, 9, 10, 19, 22, 44), caused the greatest decrease in bloom. However, the copper-containing treatments, as a group, gave some decrease in bloom, particularly when used with calcium arsenate. Organics, such as Zerlate and Fermate, encouraged blooming to some extent. Most of the plots treated with DDT bloomed more profusely than the untreated checks, and this material even counteracted the depressing effect of the copper-containing compounds to a considerable degree. Some of the combinations of DDT and an organic fungicide bloomed most heavily, for instance Zerlate plus DDT (treatment 19 in Table 9). Not only were there more and larger flower clusters on the plots treated with DDT than on those that received calcium arsenate, but they were also more persistent. There was little correlation between profusion of bloom and final yield, but in general the plots which bloomed heavily also yielded well (18).

There was a marked contrast between the leafhopper populations of the plots treated with calcium arsenate and with DDT in this experiment. There were no leafhoppers on the plants treated with DDT, whereas some of the plots that received calcium arsenate showed populations nearly as high as the untreated checks. The situation with respect to aphids was nearly as striking. It would be difficult to find a better demonstration of the effect of calcium arsenate in increasing the aphid populations on plants treated with it than that which occurred in this instance. DDT gave excellent aphid control in this experiment, but it has since been found to actually encourage the development of aphids on such crops as cucumbers. The control of flea beetles by DDT was not so outstandingly better than that obtained with calcium arsenate, but it did greatly reduce the damage caused by that insect.

The control of defoliation by the different treatments is indicated in the last column of Table 9. The average percentage of dead foliage for six fungicides when they were used with calcium arsenate was 40 percent, whereas it was only 25 percent when the same materials were used with DDT. The lesser insect damage on the DDT-treated plots accounted for some of the difference in defoliation, but it is also possible that early blight infection was facilitated by the greater amount of insect damage on the plants that received calcium arsenate (25). When the paired foliage scores for each of these six fungicides were averaged for each insecticide, it was found that Zerlate (ziram) gave the best control of defoliation, followed in decreasing order by Bordeaux mixture, Dithane, Fermate, COC-S, and Tribasic. The plots treated with DDT only were greener on July 26 than most of those that had received a fungicide plus calcium arsenate.

The yields (shown in first column of Table 9) of those plots that were treated with DDT were significantly above those treated with calcium arsenate. A comparison of the same six fungicides used above shows the average yield with calcium arsenate to be 355 bushels per acre, whereas it was 503 bushels when DDT was the insecticide. Only a few of the treatments that included the arsenate increased the yield significantly over that of the untreated check, regardless of the fungicide used. On the other hand, all of the yields from plots treated with DDT were significantly above that of the untreated check. DDT used as a spray (treatment 14) and as a dust (treatment 24) was equally effective in all categories. Extending the spray interval from 10 up to 20 days resulted in some decrease in insect control and in yield. The use of 75 pounds of DDT-talc dust per acre gave no gain over a 50-pound application. The nutritional formulations (treatments 5 and 8) gave no yield increase over their corresponding single fungicide counterparts (treatments 4 and 6).

Since DDT was a comparatively new insecticide in 1945, it was decided to study its use on potatoes in some detail. Data relative to a series of tests conducted at Wooster are given in the various sections of Table 10. In Section A, DDT was used with three different Bordeaux formulations and was alternated with it in another treatment and added to it in only every other application in another. There were no significant differences in disease and insect control in these five treatments. Flea beetle damage was most noticeable with the alternating treatment, perhaps due to a lessening of the protective action of the fungicide. There were very few leafhoppers or aphids present on the plots in this experiment and no data relative to their control are given. The plants bloomed most profusely in the plots treated with the weakest Bordeaux formulation (treatment 3 in Section A).

In another portion of the experiment, DDT was used in progressively smaller quantities, as indicated in Section B of Table 10. The amounts indicated refer to the actual weights of DDT used in each 100 gallons of spray material, the wettable powder having been formulated to contain 25 percent of DDT. One-sixteenth of a pound of DDT in 100 gallons was found to be too little and as a result the foliage condition was comparatively poor, blossom production and yield were down, and flea beetle damage was rather severe. One-eighth pound (½ pound of the 25 percent formulation) was much better in all performance criteria, and at one-fourth pound the results were approximately comparable with those given by larger quantities.

In Section C of Table 10, the data relative to various DDT formulations are given. DDT preparations furnished by various manufacturers were compared, both as wettable powders and as emulsions. The comparative effectiveness of this chemical when formulated with different diluents as bentonite, clay, talc, and lime was also investigated.

Wettable powder formulations from two different manufacturers (treatments 13 and 14) were comparable in performance. This was also true for emulsions from four different sources, except for the fact that one of these was somewhat injurious (phytotoxic) and failed to maintain the yield average of the rest of the group. Among the formulations prepared to test the influence of the diluent on DDT performance, it was found that lime was unsatisfactory from a physical standpoint and that the resulting mixture was somewhat inferior in other respects. In comparisons between DDT, Z39 (DDD), methoxychlor, and BHC (treatments 19, 12, 20, and 21, respectively), it was indicated that Z39 was slightly inferior to DDT, as was methoxychlor. BHC and DDT were more nearly alike in performance.

Calcium arsenate and DDT were compared further in their ability to control various potato insects in an experiment at Marietta in 1945. The data relative to this experiment are given in Table 11. Each of these two insecticides was used with five fungicides. The average number of flea beetle punctures per 10 leaves when calcium arsenate was used with the 5 fungicides was 71, whereas there were only 12 punctures with DDT. The corresponding differences with respect to leafhopper nymphs per 10 leaves were even greater, with an average of 50 per 10 leaves for calcium arsenate and only 1.4 for DDT. Aphids were present in considerable number on all plots regardless of treatment. The average on 10 leaves from the 5 plots which received the arsenate was 282, and there were 84 on the same number of leaves in the DDT plots. The corresponding average yields on these plots were 336 and 414 bushels per acre, respectively. Late blight was present in this experiment and became comparatively severe before the end of the season. The average degree of infection for the five fungicides used with calcium arsenate and with DDT was approximately the same, as was the average percentage of defoliation, on July 11.

DDT used alone, or with Dithane, was superior to Z39 (DDD) in all categories. Z39, on the other hand, gave better control of leafhoppers and aphids than did LB72 or calcium arsenate. However, the arsenate gave the best control of flea beetles. The plots treated with Dithane plus calcium arsenate yielded more than those treated with LB72 or Z39, although the increase was far from significant. Zerlate gave less control of late blight than did Bordeaux mixture, but in spite of this it gave the better yield whether used with calcium arsenate or DDT. Zerlate also gave better results than did Fermate. When Zerlate alternated with DDT was compared with Bordeaux and DDT alternated, the former was poorer in all categories. As a result, the plots treated with Bordeaux yielded much more than those that received Zerlate. This indicates that Zerlate is much less effective as a late-blight fungicide when applied only every 20 days than is Bordeaux mixture.

Many of the formulations used on potatoes at Wooster in 1945 (Table 9) were also applied to another planting at Marietta. The data relative to this experiment are given in Table 11. The results were much the same as those obtained at Wooster. The average yield when 5 different fungicides (treatments 1 to 5, inclusive) were used with calcium arsenate as an insecticide was 336 bushels per acre, but when DDT was substituted for the arsenate the average yield was increased to 414 bushels. This occurred in spite of the fact that there was little difference in the average percent of defoliation on the two groups of plots on July 11, at which time two-thirds of the leaves on the untreated check plots were dead. Late blight was slightly more prevalent on the plots that received DDT than on those treated with calcium arsenate.

Flea beetle punctures were much less numerous on the plots that were treated with DDT than on those that were sprayed with the formulations that contained calcium arsenate. In spite of this apparent toxicity of DDT to flea beetles, not all of them were prevented from feeding, and the experience of the last few years has been that DDT may actually give comparatively poor protection against damage to potatoes by this insect. Perhaps some resistance to DDT is developing in the potato flea beetle. DDT, in line with general experience, gave almost complete control of the leafhopper, aphids were greatly reduced but still far from eliminated by DDT, but calcium arsenate gave very little control.

LB72 was very similar in overall performance to calcium arsenate and fell far short of DDT in most categories. Z39 (DDD or Rhothane) gave fair control of leafhoppers, a slight reduction in aphids, and comparatively poor control of flea beetles. DDT used alone (as a dust in treatment 16) gave somewhat better control of flea beetles and aphids than did Z39. DDT used in alternating schedules with Bordeaux mixture and with Zerlate, which means that it was applied every 20 days, fell off slightly in flea beetle and leafhopper control. Aphids became very numerous on the Zerlate-DDT schedule but were comparatively scarce where Bordeaux was alternated with DDT. The reason for this difference between the two schedules is not apparent.

An even larger series of treatments was applied to muck-grown Irish Cobblers at McGuffey in 1945. The data relative to this experiment are given in Table 12. The comparative performance of calcium arsenate and DDT when used with five different fungicides was similar to that already discussed for Wooster and Marietta (Tables 9 and 11, respectively). DDT gave an average yield that was 128 bushels per acre in excess of that obtained with calcium arsenate. Flea beetles were not very numerous and the degree of feeding was about the same on plots treated with the two different insecticides. Leafhoppers and aphids, on the other hand, were much more numerous on the plots treated with calcium arsenate than on those sprayed with the fungicide-insecticide formulations that contained DDT. Defoliation near the end of the growing season was more severe on the DDT-treated plots than on those sprayed with calcium arsenate.

The addition of calcium arsenate to Bordeaux did not improve the performance of the latter to any noticeable extent. Instead, the aphid population was greatly increased when the insecticide was added. The addition of $ZnSO_4$ plus lime to Tribasic gave a reduction in defoliation but no increase in yield in this experiment. A nutritional carbamate mixture (treatment 9 in Table 12) was no better than Zerlate. Methasan and Zerlate, which are identical chemically, were very similar in performance. Fermate was also similar to Zerlate, as was a nickel carbamate (treatment 12).

An 8-8-100 Bordeaux mixture, used with DDT gave a considerably higher yield than a 4-4-100 and somewhat higher than a 6-6-100, although it was no better than either of the lesser concentrations in insect control. When Bordeaux and DDT were used in alternate applications, the yield fell off sharply. Sulfur with DDT gave a good yield and good insect control, although the foliage condition near the end of the season was comparatively poor. Several fungicides, all used with DDT, were similar in overall performance. Z39 (DDD) gave results similar to DDT when used with Dithane, which was somewhat different from the results obtained at Marietta and Wooster. In an average of the three experiments the yield for DDD was 371 bushels per acre, whereas it was 430 bushels with DDT. When DDT was left out of every other application of Bordeaux mixture, there was only a slight drop in yield (treatments 16 and 20), and leaving it out of every other application of Zerlate had no appreciable effect (treatments 27 and 28).

The Wooster experiment relative to the performance of different DDT formulations was repeated at McGuffey in 1945. The data for McGuffey are given in Table 13.

The yield, foliage, and insect data relative to six concentrations of DDT (treatments 5 to 10, inclusive) indicate that there is little to choose between the use of 1 pound and ½ pound in 100 gallons, but that 1/16 pound is too little. Why ⅛ pound gave a higher yield than ¼ pound in this experiment is not apparent. DDT formulations prepared as wettable powders by different manufacturers (treatments 11 to 15, inclusive) were not significantly different in performance. The use of different carriers in the formulation of DDT (treatments 16 to 19, inclusive) had little influence on the insect control and the yield given by the insecticide in this experiment. Even lime failed to give a decrease in yield in this instance, although the mixture of DDT and lime was somewhat lumpy.

When differently prepared DDT emulsions were compared (treatments 20 to 23, inclusive), little difference in performance was noted. The foliage condition on these plots was comparatively good. A comparison between the group of wettable powder formulations and the emulsions shows an average yield of 532 bushels per acre for the powders and only 359 bushels for the emulsions. The difference was not nearly as great at Wooster, where the powders gave a yield of 515 bushels per acre compared with 501 for the emulsions. DDT applied as a dust was somewhat inferior to the spray applications in this experiment. Z39 (DDD) was again inferior to DDT, as were methoxychlor and BHC.

When DDT was applied in the same formulation every 10, 15, and 20 days (treatments 2 to 4, inclusive), there was comparatively little difference in foliage condition, insect control, or yield. This, together with other evidence collected in 1945, indicates that DDT is probably used in excess and applied more frequently than is necessary for the control of leafhoppers, and possibly aphids. This is definitely not true with respect to flea beetles, however. Many of the formulations used on Irish Cobblers in some of the 1945 experiments were also applied to the Sebago variety at Wooster. The data relative to this test are given in Table 14.

DDT was again superior to Z39, methoxychlor, and BHC in the control of flea beetles, and it did not favor an increase in the aphid population as did Rhothane and methoxychlor. As a result, plots treated with DDT gave a larger yield than the other three insecticides. There was little difference between the DDT formulations prepared by different manufacturers, nor between the emulsions and the wettable powders. When three rates of DDT were compared (¼, ½, and ¾ pounds of actual DDT per 100 gallons), there was little difference in insect control, foliage condition, or yield. DDT used as a dust (treatment 14) gave as good control of flea beetle damage as did a spray formulation (treatment 7), but there was a greater aphid population with the dust than with the spray. As a result, the yield was considerably less.

The average yield when calcium arsenate was used with four different fungicides (treatments 15 to 18, inclusive) was 224 bushels per acre, and this was increased to 381 when DDT was substituted (treatments 21, 24, 25, and 26). The corresponding defoliation percentages were 59 and 33, respectively. There was little difference in the amount of flea beetle damage with the two insecticides, but the average aphid population was much higher with calcium arsenate than when DDT was used—288 aphids per leaf compared with only 28.

DDT used with Dithane (treatment 27) gave a lower aphid population and a considerably higher yield than when either calcium arsenate or LB72 was used (treatments 19 and 20).

Aphids became severe in another potato experiment conducted at Wooster in 1945 and the data relative to the use of DDT and calcium arsenate with four different fungicides are given in Table 15. The variety used in this instance was Erie.

DDT used alone gave a much better yield, largely due to low populations of aphids and leafhoppers, than did calcium arsenate used with various fungicides. DDT was definitely superior to BHC when both were used with Fermate.

When four different fungicides were used with calcium arsenate (treatments 2, 3, 4, and 5), each formulation favored such a large increase in the aphid population that the resulting yield was below that of the untreated check. This "build-up" in aphids did not occur when DDT was used, and, as a result of this and the control given of leafhoppers and early blight, there was an average yield increase of 80 bushels per acre (21 percent) over that of the untreated check.

The experiments on potatoes in 1945 centered around a comparison of DDT and calcium arsenate for insect control and the comparative effectiveness of some of the new organic and the older copper-containing fungicides. The data in Table 16 represent a partial summary of the performance of some of these materials when used in four different experiments, three of which were at different locations.

DDT proved to be much more effective in the control of leafhoppers than calcium arsenate when used with four different fungicides. Calcium arsenate plus either Bordeaux or COC-S gave considerably lower leafhopper counts than when the same insecticide was used with either Fermate or Zerlate. This difference in control with the two types of fungicides was undoubtedly due to the presence of the copper in the Bordeaux and COC-S (1).

A reduction of 90 percent in the leafhopper population with Bordeaux plus calcium arsenate resulted in only a small increase in yield (6 percent) over the untreated check. This indicates that the final 10 percent of leafhoppers left unkilled (0.6 nymphs per leaf) were very important in reducing yield since their complete elimination with DDT resulted in a yield increase of about 53 percent over the untreated plots. The small yield increases obtained with Bordeaux plus calcium arsenate in 1945 (Table 16) was due, partially at least, to the large increase in the aphid population that accompanied the use of calcium arsenate. This large increase in aphids, over those present on the untreated check plots, did not occur where DDT was used.

A summary of the results obtained in spraying potatoes in 1945 would read somewhat as follows: DDT gave a considerably greater reduction in the damage due to feeding by flea beetles than did calcium arsenate, and DDT gave a greater degree of residual protection against the flea beetle than did any of the other insecticides used in 1945. DDT used as a dust gave results that were similar to those obtained with a spray formulation, except that there were somewhat fewer aphids when sprays were used. Emulsifiable oil formulations gave a degree of insect control similar to that obtained with the wettable powders, but they did cause some plant injury in some instances. DDT showed little or no fungicidal action. Bordeaux and DDT proved to be comparatively effective over a period of 20 days when used in alternate applications, with DDT seemingly somewhat more durable than the Bordeaux mixture. Zerlate gave slightly higher yields than Bordeaux in the absence of late blight, but the reverse was true in the presence of the disease. There was little difference in the yield or in disease and insect control resulting from the use of 4-4, 6-6, or 8-8-100 Bordeaux formulas. There was some indication that the 4-4-100 Bordeaux might be depended upon to give better results with DDT than with calcium arsenate. Comparison of DDT formulations varying from 1/16-100 to 1-100 indicated that DDT is probably used in excess of the amount necessary for the control of all potato insects except flea beetles. DDT formulation prepared by various manufacturers were approximately equal in control effectiveness. Rhothane, methoxychlor, and BHC were all somewhat inferior to DDT for use on potatoes.

1946

In 1946, the practice of carrying on identical experiments at Marietta, Wooster, and McGuffey was continued (23). The data relative to these experiments are given in Table 17. The use of DDT as the insecticide with which the various fungicides were formulated in these experiments resulted in a high average yield (23). This was largely due to the fact that leafhoppers and the damage they cause were almost wholly eliminated by the presence of this very effective insecticide on so many of the plots.

A considerable number of the newer fungicides were included in the list used in these experiments and the yields obtained with some of them gave a hint of the waning popularity of Bordeaux mixture as a potato fungicide that was to come. As it happened, this decrease in favor was hastened by the fact that its insecticidal properties were made quite unnecessary by the highly efficient action of DDT. However, Bordeaux was still used as the fungicide with which the different insecticides used in the experimental series were formulated. Also, since there was some question concerning the influence of an excess of the lime fraction in the Bordeaux formula on the effectiveness of DDT, its lime content was varied from 16 to 4 pounds in 100 gallons of spray material.

Four insecticides were included in these three-way experiments. The average yield for DDT was 468 bushels per acre and this decreased to 404, 384, and 382 for methoxychlor, Rhothane and BHC, respectively. The plots treated with DDT also showed fewer leaf punctures caused by flea beetles than those that received any of the other three insecticides. The Bordeaux plus DDT formula (treatment 9) plots alho showed a better foliage condition at the end of the season than did those treated with the other insecticides.

At least 11 fungicides besides Bordeaux mixture were included in these experiments, five of which contained copper, and the remainder were organic in nature. Five belonged to the comparatively new group commonly designated as the dithiocarbamates. Manzate, or maneb, a fungicide which has since proved to be very useful on tomatoes, was used for the first time on potatoes in these tests. Ferbam, as Fermate, which was included for what proved to be one of the last times it was used experimentally on vegetables, was comparatively ineffective as a potato fungicide. Ziram, as Zerlate, failed to control late blight effectively, but it was the equal of Bordeaux in the control of early blight. Zineb, as Dithane and Parzate, gave good disease control and high yields, but the top yield was obtained with a mixture of Zerlate and Parzate. All of these dithiocarbamates, with the exception of Fermate, gave a higher average yield and a better foliage condition for the three locations than did Bordeaux, when all were used with DDT.

The average yields and foliage conditions were approximately the same for the different Bordeaux formulas that were used. The 6-6-1-100 formula was slightly better than the 8-8-1-100 or the 4-4-1-100. The fact that the yield and foliage condition were as good with 16 pounds of lime as with 8 or 4 indicates that the extra amount of lime had not seriously decreased the effectiveness of the DDT with which it was used.

Of the five copper-containing compounds that were used, Bioquin gave the highest average yield, and Crag 169A the best foliage condition. Both gave better results than the best of the Bordeaux-mixture formulas. The other materials in decreasing order of average effectiveness were COC-S, Tribasic, and Copper Hydrate.

Three dust mixtures were included in this experimental series. The Zerlate plus DDT combination gave a high yield and excellent foliage condition. COC-S plus DDT was somewhat poorer, but both of these formulations gave good flea beetle control. The copper-lime-DDT dust mixture gave a comparatively poor average yield and foliage condition, and it is possible that the lime in this instance decreased the effectiveness of the DDT as an insecticide.

A summary of this three-location experiment on Irish Cobbler potatoes shows that DDT used with Bordeaux mixture increased the yield by 34 percent, or 121 bushels per acre, over Bordeaux alone. DDT eliminated the leafhoppers from plots treated with it and gave better control of flea beetles than did Rhothane, methoxychlor, or BHC. It (DDT) gave moderate control of the green peach aphid but was less effective against the pink and green potato aphid. BHC gave comparatively good control of aphids. Zerlate was equal to, or better than, Bordeaux mixture in the control of early blight, but was less effective in the control of late blight. Zineb gave good control of late blight and a mixture of zineb and ziram gave very good control of both early and late blights. The Zerlate-DDT-talc and COC-S-DDT-talc dust mixtures gave equally as good results as the same fungicides applied as sprays. DDT used with copper-lime dust was less effective as an insecticide than when used with a high-lime Bordeaux mixture.

Various treatments were used at Wooster in addition to those listed in Table 17 and the data relative to these are given in Table 17A. The addition of bentonite, Omilite and Florigel to COC-S did not add anything to disease control efficiency and the yield given by COC-S used alone. The addition of $ZnSO_4$ and lime to Tribasic gave better results than Tribasic used alone. Copper phthalate proved to be somewhat phytotoxic and thus gave a comparatively poor yield.

Guantal also gave rather poor results as a potato fungicide. The use of Methasan (ziram) gave good disease control and one of the highest yields in the experiment. Omilite, which is an adhesive with mild fundicidal properties, gave fair disease control and one of the highest yields in the experiment. This was also true of Zn MBT (treatment 39). When 4-metal dimethyl and ethylene bis dithiocarbamates were used (treatments 42 and 41, respectively), they gave comparatively good control of disease and fairly high yields.

A planting of late potatoes (Katahdin) was sprayed with several copper-containing and organic fungicides, and with Zerlate in an alternating schedule with Parzate, with COC-S, and with Bordeaux. Early blight had caused a considerable loss of foliage in the check plots by the end of September. The data relative to this experiment are given in Table 18.

Not all of the treatments used in this experiment gave a significant increase in yield, due in part to poor disease control but chiefly because of the dry weather in the late summer and fall. Most of these treatments contained copper in one form or another. All of the organic fungicides gave a significant yield increase, except Zerlate and Bordeaux in an alternating schedule. In this instance there was some injury of the foliage as well as an apparent lack of compatibility between the two fungicides.

The average yield for the copper-containing fungicides was 281 bushels per acre compared with 298 bushels for the plots treated with the organic compounds. The average percentages of defoliation, chiefly due to early blight, were 29 and 22, respectively. The average number of blossoms on the differently treated plots, when that on the untreated check plots was taken as 100, was 160 for the plants that had received copper and 200 for those treated with organic compounds.

One of the interesting features of this experiment was the response of the plants in the differently treated plots to a marginal frost (33° F.) that occurred on October 2 (15). The data of Table 18 show the percent of foliage considered to be dead on the differently treated plots on September 28 before the frost and the percentages still alive on October 4 after the frost. From these two sets of values the percentage of the live foliage on September 28 that was killed by the frost has been calculated. These percentages are listed for the plots that received the different treatments in the next to the last column of the table. A considerably larger percentage of the foliage existent on the copper-treated plants was killed by the light frost than was injured on the plots that had been sprayed throughout the season with the organic fungicides, most of which contained zinc. The comparative average values were 89 percent of the foliage killed on the copper plots and only 52 percent on those sprayed with the organics. The reasons for this difference in frost susceptibility are not clear, but the fact remains that the plants that had been treated with copper all season were more severely injured than those that received zinc (22).

Various investigators have observed that not all varieties of potatoes have the same resistance to the attack of diseases and insects, nor do they have the same response to unfavorable environmental factors and to the application of spray materials (12, 24). In 1946, the authors planted 10 different varieties of potatoes at Wooster and McGuffey. These 10 varieties represented the near maximum in difference in maturity periods, with 90 days for Warba and 140 days for Sequoia. Each planting was divided into separated but closely adjacent halves. One half of each planting at each location was then sprayed with a mixture of COC-S plus DDT (4-1-100). The different responses of each variety to the spray treatment were then observed. The data relative to the Wooster planting are given in Table 19 and those for the McGuffey planting in Table 20.

Damage from early blight, flea beetles, and leafhoppers was rather severe at Wooster, but late blight was absent. At McGuffey both early and late blights were present in the planting, but flea beetles were scarce and leafhoppers were difficult to find. Rather complete data relative to disease and insects were obtained at Wooster but only yield data are available for McGuffey.

The data of Table 19 indicate that leafhoppers were comparatively scarce on the unsprayed plants of Sequoia, Erie, Russet Rural, Chippewa, and Katahdin, whereas they were much more numerous on Irish Cobblers, Pontiac, Warba, and Bliss Triumph. Sequoia is somewhat resistant to flea beetle damage and Pontiac is quite susceptible to injury. Sequoia and Sebago possess some natural resistance to late blight, whereas all of the others included in these plantings are rather susceptible to attack by this disease.

At Wooster the four varieties that showed the highest leafhopper populations in the unsprayed block gave the greatest response to spraying with COC-S plus DDT. The average leafhopper population was 3.7 nymphs per leaf and the yield increase was 135 percent. On the other hand, the average nymph population per leaf was 2.0 for Sequoia, Rural, Erie, and Sebago, and the percentage of increase in yield due to spraying was only 95. This response in the form of a yield increase to the control of the leafhopper confirms the results obtained by the junior author who found that Bordeaux mixture, which gives some degree of control of potato leafhoppers, gave the greatest yield increase on Bliss Triumph and the least on Sequoia. Pontiac, which is quite susceptible to disease and insect attack, gave one of the largest increases in terms of bushels per acre when it was protected by a fungicide-insecticide spray. The averages of all the data for the 10 varieties show that yields were doubled, defoliation was halved, leafhoppers were completely eliminated, and flea beetle damage was reduced by 80 percent by spraying with COC-S plus DDT at 10-day intervals.

As mentioned previously, insects were scarce in the variety planting at McGuffey but early and late blights caused considerable defoliatian of the unsprayed section toward the end of the season. Only data relative to yield and the increases due to spraying are given in Table 20 for this McGuffey planting. The yields in the unsprayed portion were comparatively high, and for this reason the percentages of increase due to spraying were seemingly low, even though the actual increases in terms of bushels per acre were comparatively large. Except for Russet Rural, which had a low unsprayed yield, the same three varieties that showed the best response to spraying at Wooster (Warba, Bliss Triumph, and Pontiac) repeated at McGuffey. Sequoia showed a comparatively small response to spraying, which is more nearly what would be expected than was true at Wooster. The average yield increase due to spraying was only 42 percent at McGuffey compared to 105 percent at Wooster. This indicates that insect control may be more effective in increasing yield than the control of disease.

Most of the fungicide and insecticide comparisons made on potatoes during 1946 involved the use of sprays, but in one experiment all of the compounds being tested were prepared as dusts. The data relative to these formulations are given in Table 21. In this experiment COC-S and Zerlate were both used in the usual amounts and applied at 50 pounds per acre. In another mixture where the fungicidal ingredient was present in twice the usual amount, the mixtures were applied at only 25 pounds per acre. Different diluents and adjuvants were used with COC-S. Other fixed coppers were compared with COC-S, as well as with various organic fungicides. Other insecticides were compared with DDT, and in one instance part of the lime in the usual copper-lime dust mixture was replaced with talc.

Early blight caused considerable defoliation of the plants in this experiment before the end of their growth period, but the disease was of no more than medium severity even on the untreated check plots. Late blight caused the loss of a small percentage of the leaves in plots treated with some of the dust formulations. It (late blight) was finally responsible just at the end of the season for the death of most of the leaves still remaining alive in the check plots.

A concentrated dust, prepared with COC-S as the fungicide, was not as effective in disease control and in increasing the yield as was the regular 7 percent formulation applied at the usual rate of 50 pounds per acre. When two Zerlate formulations were compared in the same way, the degree of disease control was equal but the yield from the plots treated with the concentrate was slightly, although not significantly, larger. The substitution of Diluex for EM23 Talc resulted in some decrease in the control of disease and in yield, but the use of Florigel in place of 8 parts of talc had no effect on yield. The results obtained with Tribasic, Copper Hydrate, Bioquin, and Cuprocide were not significantly different in yield and disease control from those obtained with COC-S.

In a group of several organic fungicides, Fermate was considerably less effective than Zerlate. Manzate used alone, or to replace half of the Zerlate in one formulation, was no better than Zerlate. Parzate and Dithane Z-78 were two of the most effective compounds tested, both from the standpoint of disease control and yield increase. Nickel ethylene bis dithiocarbamates gave results that were comparable to those given by many of the fungicides used in this experiment, but its use resulted in a yield significantly lower than those obtained with Parzate and Dithane. The use of methoxychlor and BHC to replace part of the DDT used in the usual formulation with Zerlate added little to foliage condition and nothing to yield. The use of talc to replace half of the lime in a 20-76-4 formulation did not give any increase in yield or disease control over that furnished by the usual mixture.

A review of the results obtained in this experiment indicates that there was comparatively little difference in the degree of disease control and in the yields obtained in the differently treated plots. A few of the dust formulations were obviously inferior but the majority of them were very closely grouped on the basis of the yield and foliage condition of the plants treated with them.

All of the dust formulations were applied with a new type of duster (20) developed in the U. S. Department of Agricultural Engineering Laboratory located at Toledo, Ohio. This duster can be accurately calibrated to apply a wide variety of dust formulations with very little variation from a chosen rate per acre.

DDT was used with COC-S in amounts ranging from one pound per acre down to one-eighth pound. The data relative to yield and foliage condition are given in Table 22. One pound of DDT in 100 gallons of spray formulation gave the best foliage condition and yield, and ⅛ pound gave the poorest, but yields and defoliation scores did not vary to any appreciable extent when DDT was used at ¾, ½, and ¼ pound per acre.

Other data given in Table 22 show the effect of varying the copper-lime ratio in Bordeaux mixture and the amount of water used to apply it. There was little variation in yield when an 8-8-100 Bordeaux mixture was applied at 200, 150, and 100 gallons per acre. Neither was there much difference as the amount of DDT was varied between ½, ¾, and 1 pound in 100 gallons of spray. Variations in yield as the amount of copper applied per acre was varied were also minor, being 353, 360, and 346 bushels per acre as an average for the use of 4, 3, and 2 pounds, respectively. The average yields for applications made at 200, 150, and 100 gallons per acre, regardless of formulation, were 353, 357, and 348 bushels per acre, respectively. The best yield was obtained when a 12-12-100 Bordeaux was applied at 100 gallons per acre, and the lowest resulted from the use of a 4-4-100 formulation applied at 200 gallons per acre. However, the difference between the yields from these two treatments was only 35 bushels per acre. The foliage condition was poorest with the 16-16-100 and 4-4-100 formulas and best with an 8-8-100 formula applied at 150 gallons and at 100 gallons per acre.

1947

The experiments on potatoes in Ohio in 1947 included comparisons between dust and spray formulations, both types being used in the same planting in some instances. This was true in the usual three-location experiment where 24 spray formulations were used, together with 5 dust mixtures (Table 22). Ten spray and dust formulations were compared in another experiment in the same field. In addition, at least three other experiments dealt entirely with a comparison of different fungicides applied as sprays.

The weather during the summer of 1947 was not especially favorable to the development of early or late blight, and as a result the severe epidemic of late blight that occurred over much of Ohio in 1946 was followed by only scattered and comparatively mild outbreaks during 1947. Early blight appeared about mid-summer in most of the experimental potato plots and caused a medium to severe degree of defoliation, depending on the location and the date of maturity of the crop in the different plantings.

Cobblers were planted at Marietta in late March. Vine growth was good during the summer and the yields at harvest were comparatively high. Late blight was not found in the planting, but early blight had caused a considerable degree of defoliation in the untreated check plots by mid-July. As a result the yields were depressed considerably. The data on yield and defoliation at Marietta are given in Table 22, together with data for the same series of treatments at Wooster and McGuffey. The comparison between insecticidal compounds was made by formulating them with COC-S, and DDT was used with all of the fungicides. DDT was used also without a fungicide in these three experiments as a check on what insect control alone might do in the way of improving the foliage condition and increasing the yield. The same procedure was used with Bordeaux mixture (treatment 3). The two used together gave much better results than either used alone, as would be expected. When five different insecticidal formulations were used with COC-S, four of them were quite similar, but heptachlor was somewhat injurious and its use decreased the yield slightly below that of the untreated check.

The addition of a low solubility zinc compound and of $ZnSO_4$ plus lime to Tribasic (treatments 12 and 13 versus 11) gave some improvement in disease control and a slight increase in yield. Zerlate used alone gave as good results in this experiment as any one of several variations in its use with other materials. A special formulation of Methasan (ziram) gave slightly poorer control of early blight than did Zerlate. Bioquin gave results similar to Methasan and Zerlate, but Phygon was somewhat injurious. Copper zinc chromate gave the best disease control and the highest yield of any of the spray formulations used at Marietta.

The performance of the dust formulations at Marietta, where they were applied at an excessive rate with a hand duster, was rather remarkable. This was especially true of Zerlate and Dithane Z-78, and of Zerlate in particular. COC-S did not do quite as well in disease control or yield, but was still much better as a dust (as it was applied in this experiment) than the corresponding spray formulations of treatment 7. At Wooster where the rate of application was controlled carefully in applying the dusts with a calibrated power duster (20) their performance was not noticeably better than that of the corresponding spray formulations. This was also true in the McGuffey experiment.

There was some late blight in the Wooster planting for the three-location experiment and early blight became very severe on the untreated checks before the time came for harvesting the plots. As a result the DDT-sprayed plots were also severely defoliated toward the end of the growth period. Bordeaux plus DDT was again considerably better than either used alone, indicating here, as well as at Marietta and McGuffey, that both diseases and insects must be controlled to obtain the maximum in foliage condition and yield. Heptachlor compared more favorably with the other insecticides at Wooster, and Tribasic was not improved by adding zinc to it. Zineb gave similar results in tank-mix and wettable-powder formulations (treatments 14 and 16). In this experiment Zerlate was improved in its effect on disease control and yield by using other fungicides with it. Phygon and Bioquin gave comparatively poor results, as did Methasan, but copper zinc chromate again looked very good.

The potatoes in the experimental area at McGuffey were an excellent crop, especially in the plots that were treated with some of the better fungicide-insecticide formulations. Late blight infection occurred about mid-season and caused some reduction in yield in the untreated checks and in plots treated with materials not capable of checking its spread. Early blight appeared about the same time and became very destructive in some plots by the end of the growing season.

Leafhoppers and flea beetles were numerous in the surrounding area. As a result of all this, the foliage condition was comparatively poor in many of the differently treated plots about 10 days before the untreated check plots were completely dead. The Bordeaux and DDT checks each showed considerable defoliation, with the fungicide treatment giving somewhat the better results. When they were used together, there was a very decided increase in yield. There was comparatively little to choose between the different insecticides used with COC-S. The use of zinc with Tribasic resulted in an improvement in foliage condition and some increase in yield. The two zineb preparations (treatments 14 and 16) were similar in yield, but ziram (Zerlate) dropped behind at McGuffey. As a result most of the formulations in which something was used with Zerlate improved the foliage condition and increased the yield. Copper zinc chromate (later to be designated as Crag 658) gave the best foliage condition of the experiment and a better yield than most of the fixed coppers.

Data representing the averages in foliage condition and yield at all three locations give a good indication of the comparative ability of the different formulations used to control early, and to a lesser extent, late blight during an average season in Ohio and will be considered in detail. The use of Bordeaux alone resulted in a considerably better foliage condition near harvest time than did the use of DDT alone. The resulting average yield was somewhat larger when the two materials were used together and they gave a very definite improvement in foliage score and in yield. The foliage condition and yield were similar for four of the insecticide formulations used with COC-S, with heptachlor dropping considerably below the rest. The use of zinc with Tribasic copper resulted in some improvement in foliage condition, but very little increase in yield. All zineb and ziram formulations were similar, with an alternating schedule of Zerlate and Parzate ranking best in the organic group in both foliage condition and yield. Methasan, Phygon, and Bioquin gave comparatively poor results, but the copper zinc chromate compound gave the best average foliage score of the experiment and a yield near the top. The dust formulations looked good in the averages of foliage condition and yield, partly because of the results obtained at Marietta. COC-S was not quite the equal of ziram and zineb when all were formulated as dusts. Zerlate gave especially good results, as it frequently does in dust formulations, and especially when it is used somewhat in excess of 3 pounds per acre (40 pounds of an 8 percent formulation). DDT, both in the wettable powder and emulsifiable formulations, and toxaphene gave good control of the potato flea beetle. Chlordane (Dowklor) and heptachlor were somewhat less effective.

A second experiment in 1947 included some special formulations of copper zinc chromate, Bioquin (copper 8-quinolinolate) phthalates, mercaptobenzothiazoles, and some specially compounded dithiocarbamates. The only fungicides of the 24 treatments that later came into general use were two fixed copper compounds—Crag 658 and COC-S. Early blight caused rather severe defoliation of some of the plots before the planting was ready for harvest, and late blight could be found on plants treated with at least six formulations about mid-season. However, it was checked by dry, warm weather within a few days. The data relative to the yield and foliage condition of the differently treated plots are listed in Table 23.

All treatments except DDT used alone, and the "phthalate complex" which was phytotoxic, gave a significant increase in yield, and all gave some degree of control of early and late blights. Of the copper zinc chromate formulations, Crag 169 gave the best disease control; in fact, this was the best of the experiment. One pound of Crag 658 was slightly less effective than two, but an increase to a 3-100 formulation was no better. Crag 585 was inferior to some of the other chromates, and although the complex consisting of additional metallic chromates gave good disease control, there was no evidence of any nutritional response by the potatoes. Bioquin, containing copper (treatment 12), was definitely more effective in disease control than was the zinc formulation (treatment 13), even though the yield was no greater. The copper and the zinc phthalates proved to be comparatively poor fungicides and the complex was injurious to the potato foliage. Neither were the mercaptobenzothiazoles (treatments 18 and 19) promising as potato fungicides, and the same can be said of the specially prepared dithiocarbamates represented by treatments 20, 21, and 22.

Zac (a ziram formulation) gave excellent control of early blight and the highest yield of the experiment. COC-S was only average in both categories, being about as good as Crag 658. With Zac giving the best results of the entire list of treatments, and considering the fact that it is usually somewhat inferior to various zineb formulations in disease control, it would seem that none of the organic formulations, at least, was good enough to compete with zineb as a potato fungicide.

The copper zinc chromate formulations and the dithiocarbamate variations of the previous experiment were applied to a somewhat later planting of Katahdin potatoes and the data relative to these are given in Table 24. Early blight was again of medium severity and a comparatively good comparison of the ability of the formulations used to control that disease was obtained. Crag 658 in the 2-100 formulation (treatment 2) and Zac (treatment 15) are the treatments with which all others should be compared. All treatments gave a significant increase in yield over the untreated checks, although this was barely true for treatment 12. The highest yield was again realized from the Zac-treated plots, but the chromate "complex", together with Crag 658 (3-100) and Crag 640, gave the best control of early blight. There was little to choose between the three formulations of Crag 658, with the 3-100 formula being slightly the best of the three. The chromate complex (treatment 11) gave good disease control and one of the best yields of the series in this experiment. The specially formulated dithiocarbamates (treatments 12, 13, and 14) again gave comparatively poor blight control and yields lower than the average for the experiment.

The possibility of improving fungicidal dust formulations for the control of potato diseases (early and late blight) was investigated further in 1947. In this instance, oils and water were added to the usual dust formulations, some in a mechanical mixer and some directly into the duster hopper, in an effort to improve adhesion and thus disease control. COC-S was used as the fungicidal ingredient and EM23 Talc was the principal diluent. Diluex was included in most formulations in a further effort to increase adhesion, and this was compared with Celite, and all formulations were compared further with a simple formula consisting only of COC-S and EM23 Talc. The data are presented in Table 25. The untreated check is listed with a series of spray formulations which make up the second portion of the table.

All treatments gave some control of an attack of early blight which was severe enough to cause a considerable degree of defoliation of the untreated check plants. Late blight was present only briefly in the planting at mid-season. Several treatments failed to give a significant increase in yield over the check plots, however, and it is doubtful if the addition of oil in the various formulations where it was used added anything to their ability to control disease. The use of 8 percent of Corvus oil apparently resulted in some decrease in yield although foliage injury was not observed. The COC-S-talc formulation was the equal of any of the others used in the series.

The use of adhesive materials with COC-S was continued, this time in spray formulations, in the treatments listed in the second section of Table 25. In addition to the four COC-S-containing formulas, Bordeaux and four organic fungicides were included. All treatments gave a considerable degree of disease control, and all but Phygon gave a significant increase in yield over the untreated check plots. Bordeaux mixture gave the best control of the mixture of early blight and a sprinkling of late blight of any treatment, although it was exceeded in yield by some of the other formulations used, particularly Parzate (zineb). Zerlate (ziram) gave the poorest disease control, and Phygon the lowest yield. None of the three adhesives used with COC-S (treatments 11, 12, and 13) improved the foliage condition over that on the plots treated only with COC-S plus DDT. Two of them gave some increase in yield.

The same list of fungicides used in the previous experiment (second portion of Table 25) was applied to another planting of potatoes 2 or 3 miles distant, where early blight caused somewhat less defoliation and late blight was less active. The data relattive to this test, and for the corresponding treatments in the first planting, are given in the first portion of Table 26. In this second planting Parzate gave the best disease control, but Bordeaux exchanged positions with it in giving the highest yield. The other treatments ranked somewhat as before, except that Phygon gave somewhat better results in disease control and yield in this experiment.

The data in the middle portion of Table 26 are included only as a comparison of ziram and two fixed coppers in the control of early and late blight. Zac (a modified ziram formulation) gave the best yield in both instances, but it gave better control, in comparison with the fixed coppers, of early than of late blight. That blight control was important in determining foliage condition and yields is shown by the comparatively high percentage of defoliation and low yields of the plots treated only with DDT.

The treatments listed in the last (third) portion of Table 26 were applied with a steam jenny. The fungicide formulations were introduced into the steam line just as the hot water was released to form steam. This resulted in the formation of extremely small droplets which were propelled toward the potato foliage by the force of the escaping steam. Coverage was good considering the extremely small volume of water involved, but disease control was not as good as that obtained when the same fungicides were applied by the conventional method used in the first portion of Table 26 (treatments 1, 2, and 3, respectively). Neither were the yields as good. Thus, this method of spray application to a row crop had little to recommend it.

1948

The experiments on spraying potatoes with various fungicide and insecticide formulations and combinations of these followed much the same pattern as that established in the Plant Pathology and Entomology Departments during the past several years (29). A three-location experiment involving 30 different treatments was again planned for

1948. The Muck Station at McGuffey was abandoned in 1947 and a new one to be established at Celeryville, near Willard, Ohio, was not yet in operation. Because of this it was decided to place the third portion of the experiment on the Osborne Welfare Farm at Sandusky on the shore of Lake Erie.

Irish Cobbler potatoes were planted at all three locations. Six different insecticides were combined with COC-S as a fungicide and 16 different fungicides were used with DDT as the insecticide (Table 27). In addition, several treatments involved modified formulations of one or more of the 16 fungicides, and in at least two instances certain fungicides were mixed together, and three others were involvd in alternating schedules. This combination of treatments was used also at Wooster and Sandusky. The weather at Marietta was more or less normal for the season, and as a result foliage diseases followed much their usual developmental pattern on potatoes. Early blight became severe during the last month of the growth period. Late blight appeared in a mild form in the untreated check plots and those treated with fungicides which were ineffective in controlling this disease. Consequently, the data obtained present a fairly representative picture of the inherent capabilities of the fungicides used to check defoliation.

All sprayed plots at Marietta were significantly better than the untreated checks in both yield and foliage condition. Parzate, which gave the highest yield in the experiment, was significantly better than all other treatments except Bordeaux, Dithane Z-78, Dithane D-14 plus $ZnSO_4$, Zerlate plus Parzate, Zerlate and Parzate alternating, and Zerlate and COC-S alternating. In foliage condition, Tribasic and Bordeaux exceeded all others, including the organic fungicides, with the exception of Dithane Z-78. Some of the ziram-containing formulations gave comparatively poor results, partly because of a lack of control of the moderate infection of late blight which occurred comparatively early in the growth period.

The weather at Wooster was somewhat favorable for the development of early and late blights during the summer of 1948, and both of them were present in the area where the Wooster portion of the three-location series had been placed. Late blight appeared in late June and persisted for about 2 weeks, after which it ceased to progress further. About that time early blight took over and was largely responsible for the final defoliation of the check plots. Bordeaux and all of the fixed-copper formulations prevented infection by late blight, and very little was present in the zineb-treated plots. All other treatments allowed some late blight infection to occur.

All treated plots at Wooster were significantly above the untreated checks in yield. Parzate gave the highest yield, but again was not significantly above several other formulations, including treatments 12, 22, 23, 26, 27, 28, and 29. L698 gave the best foliage score of the experiment, closely followed by Tribasic, Tribasic A, L658, L640, Methasan B, F629 plus 308, Dithane D-14 plus $ZnSO_4$, Parzate, Zerlate, etc. Only one treatment (Cl MBT) failed to hold the foliage condition at a level significantly above the untreated check.

The yield data obtained at Sandusky were of no value in judging fungicide performance because of the presence of large masses of undecomposed asparagus roots which had been plowed down in a portion of the experimental area in the fall of 1947. Early and late blight were present in the field during the late summer, but neither became severe enough to reduce production greatly. Dithane D-14 plus $ZnSO_4$ was selected as giving the best foliage score, but it was not significantly better in this respect than 12 other formulations. Because of the uneven growth conditions in this field, the yield data are not included in the average yield for the three locations, but the foliage condition values were. Thus, the yield averages for Table 27 represent data from Marietta and Wooster only, but the defoliation averages also include the data from Sandusky.

The yield data from Marietta and Wooster show an unusual degree of similarity with respect to the ranking of the different treatments, and as a result the average values are also similar. Parzate stood first in yield, followed closely by such zineb-containing formulations as Dithane D-14 plus $ZnSO_4$, Zerlate plus Parzate (1-1), Zerlate and Parzate alternating, Dithane Z-78, and a copper zinc chromate compound (L658). In a comparison of average defoliation scores, Dithane Z-78 ranked first, Tribasic A second, closely followed by Dithane D-14 plus $ZnSO_4$, L658, Parzate, and Zerlate and Parzate alternating. The fixed coppers and Bordeaux ranked higher as a group in foliage condition in comparison with organic fungicides in this experiment than they sometimes do. This was possibly due to the fact that some late blight was present, a disease against which copper compares more favorably with zineb than it does in the control of early blight in Ohio.

Six different insecticides, most of which were comparatively new in the experimental program, were used with COC-S as a fungicide in a comparison of their effectiveness in the control of potato insects. The average foliage conditions (percent dead) were very similar on the plots treated with these six compounds, with parathion ranking first and toxaphene last. The yield ranking was almost identical to that of foliage condition. The average yield of the parathion-treated plots was 40 bushels per acre greater than those treated with toxaphene. This excess in yield was largely the result of a much higher yield for parathion than for toxaphene in the Wooster experiment, where the excess for the former was 88 bushels per acre. At Marietta, toxaphene was slightly ahead of parathion.

Each year a number of new compounds, or new formulations of older ones, are compared with established or recommended fungicides and insecticides in preliminary trials to determine insofar as possible, the advisability of testing them further in succeeding years for the control of the foliage diseases and insects that attack vegetables. Such a list of materials makes up the bulk of the treatments listed in Tables 28 and 29. The data in Table 28 refer to yield and foliage condition values in an experiment at Wooster on early-planted Cobblers, whereas later-planted Katahdins were used to obtain the data in Table 29.

A specially formulated Methasan paste (ziram, or zinc dimethyl dithiocarbamate) gave the best yield of any treatment on the Cobblers of Table 28. A wettable powder formulation of Methasan (treatment 9) did nearly as well. In a comparison of Ca, Na, and Mg ethylene bis dithiocarbamates plus $ZnSO_4$ (treatments 1, 2, and 3), the calcium-containing formulation gave the best control of defoliation in the experiment, and all were responsible for creditable yields. Zac, with p.e.p.s. added, also gave good results in both disease control and yield. Replacing part of the Bioquin 50W in a 3-100 formulation with sulfur (treatment 7 versus 8) decreased effectiveness to the point where disease control was very poor and the yield was reduced by about 10 percent. Perhaps the best formulation in this test was the slurry form of ziram (Methasan S), and it has given consistently good results as a potato and tomato fungicide in additional tests in succeeding years. The fact that it has not received more general acceptance in disease control practice is primarily due to the fact that it is difficult to package and distribute. Also, it attacks metal (iron) containers very actively and soon destroys the drum or can in which it is packaged.

The list of treatments used in the experiment on Katahdin potatoes (Table 29) was somewhat similar to that used in the experiment just discussed (Table 28). No late blight was present in this planting and early blight did not appear until near the end of the growing season. As a result, the differences in foliage condition and yield for the differently treated plots were not very great. With the exception of L658 (copper zinc chromate) the carbamates (treatments 1 to 6, inclusive) gave the best disease control. Parzate gave the highest yield, but it was not significantly better than those obtained with Zerlate, Dithane Z-78, Zac, L658, and Tribasic. Actually the majority of the treatments were so closely similar in this experiment, where disease was not severe enough to defoliate even the untreated check until near the end of the growing season, that no one of them could be selected as outstanding, and some of the previously untried formulations compared well with others of proved effectiveness.

The study of dust formulations was continued on a reduced scale in 1948 (28), but the major emphasis was placed on the effect of varying the diluent portion of the formulations rather than that of the active ingredients as fungicides or insecticides. As shown earlier in this bulletin, dusting seldom equals spraying as a control practice, but does, of course, possess some advantages in convenience and cost. The 1948 experiments, which dealt chiefly with a comparison of various adhesive fractions in dust formulations containing Tribasic or copper zinc chromate (L658), were on early-planted Irish Cobblers and later-planted Katahdins.

After the various formulations had been prepared at Wooster, they were taken to the Agricultural Engineering Laboratory in Toledo where the feed setting of the duster (20) to be used in applying them was determined for the application rate desired for each formulation. These adjustments were then adhered to in making the field applications during the summer. This procedure was necessary since each formulation feeds through any given duster at a different rate from others used in any experimental series.

The data relative to the comparative test on Cobblers are given in Table 30. Both early and late blight appeared in the experimental area during the summer. Late blight caused comparatively little defoliation, even on the check plots, but early blight was responsible for an almost complete defoliation of the untreated plants. Various soil and drainage differences in the experimental area proved to be rather large, and as a result the yield difference necessary for significance between treatments was nearly 60 bushels per acre. This factor, together with rather narrow differences in the degree of defoliation in most of the treated plots, caused the experiment to be of little use in classifying the formulations according to their overall effectiveness.

All formulations gave a significant degree of disease control, but not all gave a significant increase in yield over the untreated check. AS 50, used at 4 percent in a Tribasic-talc formulation, gave an increase in yield but when used at 2 percent in an otherwise similar Tribasic-talc mixture it actually decreased the yield over that obtained when talc was the only diluent of Tribasic. Celite would seldom be used in formulations of this kind except as a bulking agent. The use of various quantities of Attaclay had no beneficial effect on the basic Tribasic-talc mixture as a disease control agent, and here again the principal advantage to be gained from its use would probably be only one of improvement in the physical characteristics of the formulations which included it. The results were much the same so far as the use of adjuvants with the L658-talc formulations was concerned. Celite at 10 percent decreased disease control and yield slightly below that obtained with L658-talc only. As the percentage of Diluex in these formulations was increased (treatments 6, 5, and 4), the degree of disease control and the resulting yield both decreased. The use of as much as 30 percent of Diluex was definitely detrimental. Also, the use of 4 percent of AS 50 (See Materials Key) apparently contributed little to the effectiveness of the L658-talc mixture. Zerlate, which has always given good results on potatoes when applied in a dust formulation, also did very well in this experiment.

Copper adhesion data (last column of Table 30) indicate that AS 50 increased adhesion slightly when used at 4 percent in the formulation, but this was not true at 2 percent. Celite at 15 percent increased the weathering of the copper fraction. Attaclay had little effect. Celite at 10 percent and Diluex at 20 and 30 percent decreased the adhesion of copper in the Tribasic formulas.

The same dust formulations, with one or two exceptions, were applied to Katahdin potatoes somewhat later in the summer. The data relative to the comparative tests on effectiveness are shown in Table 31. Late blight was absent in this planting and early blight did not appear until late in the growth period of the potato plants. This meant that again differences in foliage condition and yield were hardly great enough to permit any worthwhile comparisons between the disease control potentialities of the different dust formulations. A dust mixture that contained 10 percent of L658 (treatment 12) gave better results than any of the 6 percent formulations tested, regardless of the adjuvant used. Zerlate again gave better disease control than copper zinc chromate in a dust formulation, and the addition of Zerlate to the L658 gave the best yield of the experiment. In the Tribasic series the best results were obtained with the formulation that contained 4 percent of the adhesive AS 50, but since all differences were so small that the results obtained with one formulation were not significantly different from those of another, there are few worthwhile comparisons that can be made in this experimental series.

1949

The experimental work in potato spraying was conducted at four widely separated localities in 1949, namely, Marietta, Wooster, Willard, and Sandusky (30). This also represented a range of soil types and a considerable variation in the environmental complex and should have provided corresponding differences in disease development. However, the summer was rather dry and warm over much of Ohio in 1949 and as a result the foliage diseases of potatoes did not become severe enough until late September and early October to cause much defoliation, and by that time it was too late for defoliation to affect yield appreciably in most instances. Early blight developed rapidly in some plantings during the last half of September and early October and late blight infection occurred in a few fields in October.

Irish Cobblers were sprayed with 30 different formulations at the four locations mentioned above. The data relative to defoliation and yield at Marietta, Wooster, and Willard are given in Table 32. The data for Sandusky are not presented in this bulletin because of the small variations in disease control and yield that were obtained there under conditions of a severe drought during the middle portion of the growing season.

Rainfall was also somewhat below normal at Marietta. Late blight appeared in June, but did not develop sufficiently to cause much defoliation of the potato plants in the experimental area. Early blight became comparatively severe during the last third of the growth period of these potatoes, and was chiefly responsible for the almost complete defoliation of the untreated checks by August 1. This disease (early blight) was best controlled at Marietta by such materials as zineb (Dithane and Parzate) and the Methasan formulation of ziram. The fixed coppers and some of the ziram formulations were less effective in checking defoliation. Nearly all of the treatments gave a significant increase in yield over the untreated check. On the other hand, the treatment giving the highest yield was significantly better than only about one-third of the treatments used in the series. The use of p.e.p.s. definitely improved the performance of both Tribasic and Zerlate in this experiment. Fac (ferbam) was inferior to Zac (ziram). Among the insecticides used with Tribasic (treatments 2 to 7, inclusive), EPN and Compound 118 gave the best foliage condition and the highest yields. Marlate and DDT were low in both categories.

Rainfall was plentiful at Wooster until early July and temperatures were near normal. As a result potato vine growth was good. The weather turned warm and dry by mid-July and growth slowed down.

Defoliation by disease became noticeable by late July and early blight became severe in early August. Late blight appeared in the experimental plantings in late June but was checked by the warm, dry weather of July and thereafter was responsible for very little foliage loss.

Zineb, in the form of Parzate and Dithane, again gave the highest yield and the best disease control. There was little to choose between the tank-mix and wettable powder formulations of zineb, since both gave excellent control of early blight and a high yield (39). Ziram, in a slurry formulation of Zac (treatment 13), also did well, with Methasan slurry dropping down somewhat from its usual performance level. The use of p.e.p.s. with Zerlate and with Tribasic gave some improvement in disease control without a corresponding increase in yield. Fac and EM25-3 were again very poor. Parzate, the highest-yielding treatment, was significantly better than only five of the treatments that gave the lowest yields.

At Willard, where early blight became severe earlier than usual, zineb as represented by Dithane and Parzate (treatments 17, 18, 19, and 29), gave the best results in disease control and yield for the third time in the three experiments of Table 32. Copper zinc chromate and Cop-O-Zinc gave good control of early blight and comparatively good yields. Methasan and Zerlate gave similar results, and p.e.p.s. again did little to improve Zerlate and Tribasic.

The average data for the three locations present a fairly representative picture of the relative ability of the various treatments to control early blight, which was a factor in regulating yield in each instance. On the basis of these averages, zineb formulations occupy the four top places, followed by Cop-O-Zinc and two special formulations of ziram. In terms of yield the three most effective treatments were zineb-containing compounds, followed by a ziram, another zineb, and another ziram. The first copper compound appeared in seventh place. Zerlate plus p.e.p.s. occupied sixth place in both disease control and yield, well above Zerlate in disease control but similar to it in yield. P.e.p.s. also improved Tribasic considerably in disease control and somewhat in yield. Methasan in two formulations was similar to Zerlate, as was Zac. The bonding of Dithane, Methasan, and Robertson Fungicide with Diluex gave no appreciable increase in the performance of the three compounds. Fac-S was near the bottom of the performance list in both disease control and yield, as was Sporcop and EM25-3. Most of the fixed-copper formulations were intermediate in both categories, with the exception of Cop-O-Zinc, which ranked well toward the top in disease control and was at least average in yield. In general, the copper compounds ranked better in disease control than in yield.

Of the six insecticides that were used with Tribasic, Compound 118 showed the best foliage condition and second best yield. EPN was tops in yield, and parathion was second in foliage condition. Marlate was last in both foliage condition and yield. With the exception of this material, the others were closely grouped in average performance ratings.

Copper zinc chromate in some of its formulations has proved to be a good fungicide for use on vegetables. Its effectiveness in disease control varies somewhat with the various proportions of copper and zinc. In an effort to classify some of the possible formulations according to their ability to control the early and late blights of potato, a number of them were used on Cobbler potatoes at Wooster in 1949. Late blight was scarce in the planting and early blight caused comparatively little yield reduction in the differently sprayed plots, even though it did become rather severe just at the end of the growth period. As a result most of the yield differences in treated plots were too small to be statistically significant. The data relative to these comparisons are given in Table 33.

Crag 658, with its composition of 15 CuO. 10 ZnO. 6 CrO_3. 25 H_2O (as 30 percent copper and 20 percent zinc), which has come to be the more or less standard formulation for this fungicidal compound, was used as the formulation with which the variations were compared. There was no indication in this test that any of the variants were essentially better than Crag 658, nor were any of them significantly poorer.

Comparisons of a similar nature between different formulations of some of the dimethyl dithiocarbamates, as well as of others concerning the advisability of adding p.e.p.s. to various fungicides as an adhesive to improve their effectiveness, were also included in the series of treatments listed in Table 33. P.e.p.s. was used with COC-S, Zerlate, Zac, Zac-S, and Fac-S. In an average of these materials used alone and with p.e.p.s., that compound increased the yield by 12 bushels per acre and improved the foliage condition by nearly 10 percent. VL-600, a synthetic latex type of adhesive, when used with six different fungicides, did not alter either the average yield or the degree of disease control. Thus, these adhesive materials had little or no effect on the performance of the fungicides with which they were used in this experiment.

In the comparison between the different ziram-containing formulations, it is evident that the slurry formulations of Zac were somewhat better than the wettable powder and than Zerlate, in average yield, but were similar in disease control. All ziram formulations were slightly better than either of the ferbams in the form of Fermate and Fac-S. Fac-S gave the poorest disease control of the group of dimethyl formulations, although it was similar to Fermate in yield.

In another experiment at Wooster, a planting of Cobbler potatoes was sprayed with a series of new materials, and/or formulations of older ones, in a comparison of their ability to control foliage diseases (early blight in this instance since late blight did not appear). The data relative to this test are given in Table 34. Even early blight did not become active enough to cause excessive defoliation in the untreated check plots. As a result only a few of the yields from treated plots were significantly different from any of the others, although nearly all treatments gave a significant increase in yield over the untreated checks.

Halving the amount of Tribasic used reduced the yield somewhat below that given by the usual formulation. The use of adjuvants, such as Florigel, AS 50, and VL-600, had little effect in improving early blight control in these 2-100 formulations. Yields were increased slightly, but still less than that required for significance. A special formulation of Esminel gave fair disease control and an average yield. When the amount of Zerlate commonly recommended was halved, there was some lessening of disease control with little effect on yield—and again the use of adjuvants to improve control was hardly justified. In a comparison of maneb, zineb, and calcium ethylene bis dithiocarbamate (treatments 16, 18, and 19, respectively), zineb ranked first in disease control and yield, followed by maneb and the calcium salt in that order. Crag 658 gave results comparable to those of two special formulations (treatments 21 and 22). A flake-like copper formulated as a paste was comparable to Tribasic in performance.

The previous experiment was reproduced in part on a planting of Katahdin potatoes later in the season, the data for which are shown in Table 35. Foliar diseases were scarce in this planting until about September 1, after which early blight infections began to occur with increasing frequency, until by October 1 some of the treated plots had lost more than half of their foliage and the untreated checks were virtually defoliated. This was one instance in which all treatments, even the least effective, gave a significant yield increase over the checks.

The zineb formulations, represented by Dithane Z-78 and Parzate, again gave the best control of early blight and accounted for the best yields. The tank-mix and the wettable-powder formulations (treatments 23 and 26 versus 24 and 27) of zineb were almost identical in performance, as is usually true with this fungicide (39). In a comparison of ziram formulations, the slurry forms of Zac and Methasan (treatments 15 and 21) gave better disease control and yields than did Zerlate, Methasan, or Zac as wettable powders. Ferbam, as Fac-S, fell considerably below ziram in effectiveness. The bonding of Methasan and Dithane failed to improve those materials. Two special formulations of one of the dithiocarbamates in oil gave comparatively good results but the third was a failure (treatments 31, 33, and 32, respectively). Among the fixed coppers, Cop-O-Zinc again was superior to Tribasic, and Cop-O-Zinc and Crag 658 gave better results than did Tribasic, Robertson Fungicide, or COC-S. Some special copper zinc chromate formulations (treatments 12, 13, and 14) controlled early blight as well as did Crag 658. When several adjuvants were used with COC-S, all of them improved its ability to control disease, and at least two of them gave an increase in yield over COC-S alone, with p.e.p.s. being the most effective of these adhesives.

While on the subject of adhesives it might be well to discuss another experiment in which p.e.p.s. was used with a fixed copper, maneb, zineb, and ziram on large plots of Katahdin potatoes at Wooster in 1949. These data are summarized in Table 36. Since these treatments were not replicated, no value for the difference required for significance between yields can be given. Early blight caused about 85 to 90 percent defoliation in the untreated check area by October 1.

The quantity of each fungicide applied was reduced below the usual recommendation on the chance that any benefit that might accrue from the use of the adhesive could be determined more easily if the formulation in which it was included did not give the maximum control of which it was capable. The addition of p.e.p.s. did give some increase in yield in each instance, with the largest percentage of increase occurring with Parzate and the least with Methasan S. The average values, given at the bottom of the table, indicate an average increase in yield of a little over 8 percent, or 23 bushels per acre. If an increase of this amount could always be obtained, it would be worthwhile to include a good adhesive in potato fungicide formulations. However, it is possible that even in this experiment the use of that portion of the active ingredient that was left out of the original formulation would have resulted in a comparable increase in yield.

In a second experiment on the State Muck Farm at Willard, a block of late-planted Cobblers was sprayed with 16 different formulations. Early blight incidence was high in this planting and there was a scattered infection of late blight. An unusual outbreak of whitefly occurred in this experiment and it became severe enough to affect the yield in some of the plots. As a result of the action of these disease and insect attacks, the untreated checks were nearly defoliated at the time of a frost at the end of September. The foliage scores and yield data are given in Table 37.

Tank-mix Dithane and wettable-powder Parzate formulations gave the best disease control and two of the highest yields of the experiment. Methasan S gave better control of early blight than did Zerlate or Zac-S, but the yield was somewhat less. The addition of VL-600 to Zerlate and the bonding of Methasan added nothing to these materials. Cop-O-Zinc gave better disease control and a higher yield than did Tribasic. The performance of COC-S, Tribasic, and Crag 658 was very similar. This experiment furnished an opportunity to compare the frost resistance of copper and zinc sprayed plants. As mentioned earlier in this bulletin, potato and tomato plants sprayed throughout the season with zinc-containing carbamate fungicides were not as severely injured by a marginal frost as were those in the same experimental block that had been sprayed with Bordeaux and some of the fixed copper compounds (22). The same physiological response occurred in this planting of muck-grown potatoes. The plants sprayed with treatments 8, 9, 10, and 13 were more severely injured by a light frost late in September than were those in the plots sprayed with ziram and zineb.

Four different insecticides were used with Dithane D-14 plus $ZnSO_4$ in this group of treatments. These four formulations and Parzate plus DDT (treatments 1 to 5) were the only treatments that gave significantly higher yields than the untreated check plots. As indicated in the description of this experiment, a severe infestation of whitefly occurred and before it had run its course virtually all of the plots had been injured with the exception of those that had been treated throughout the season with parathion. The other three insecticides gave little control of this insect. As a result of better control of whiteflies, the plots treated with parathion had the best foliage and produced the highest yields.

Early in 1949, plans were made to compare some low-gallonage, low-pressure applications of various potato fungicides with the usual spraying procedures. These materials (five of them) were to be applied in 4X formulations at 40 gallons per acre and 80 p.s.i. (pounds per square inch) in comparison with "X" dilutions at 160 gallons per acre at 300 p.s.i. All applications were made with a self-propelled sprayer equipped with a speedometer. A separate boom bearing flat spray nozzles was used for the concentrate applications, whereas hollow-cone nozzles were used for applying 160 gallons per acre (31). The pressure drop was accomplished by shunting in a by-pass assembly between the pump and the boom that was equipped with a more sensitive pressure regulating valve and pressure indicator. The data relative to this experiment are given in Table 38.

Since the concentrate applications were to be made with only one-fourth the usual gallonage, it was necessary to make the spray formulations four times as concentrated (4X) to insure the application of the same amount of fungicide per unit of crop area. Thus, COC-S in a 4-100 formulation in the usual procedure was increased to a 16-100 formula for the concentrate application. Only early blight was present in the planting but it became rather severe before harvest, causing a high degree of defoliation in the check plots. As a result all treated plots gave a significant increase in yield over the untreated checks, in spite of the fact that disease control was not too good in some plots.

High-gallonage applications of all the fungicides used in this experiment gave better control of early blight than was obtained with low-gallonage applications. However, the difference in the degree of control was not great with COC-S and Methasan S, and in these two instances the yields were slightly better with the low-gallonage applications. Dithane Z-78 showed the greatest difference in disease control and yield in favor of the usual spraying procedure. In an average of all five treatments the data favored the high-gallonage, high-pressure applications, but the yield difference was comparatively small—less than 2 percent. It might be mentioned here that experiments performed in succeeding years, as listed in this bulletin, indicate that low-gallonage, low-pressure (concentrate) applications may give results virtually equal to those obtained with the more standard procedures.

1950

The foliage diseases of vegetables were more common than usual in Ohio in 1950, chiefly due to more than normal rainfall throughout the early part of the summer. Early and late blights of potato and tomato were unusually active, especially during July and August when the cool nights were numerous and very favorable to the development and spread of late blight (33, 34, 35). This disease was present in a mild form on early potatoes at Marietta but was scarce on the early crop at Wooster and Willard. It became unusually severe at Wooster by late August and caused almost complete defoliation of tomatoes and late-planted potatoes by mid-September in the untreated check plots of both crops. Early blight was of average severity at Marietta, Wooster, and Willard, being especially active at Willard in August.

The three-location experiment in spraying potatoes included the usual grouping of treatments, or formulations, with a fixed copper fungicide (Tribasic) being used with 8 different insecticide combinations, and DDT as an insecticide being formulated with 16 different fungicides. The yield and defoliation data for all three sites are given in Table 39, together with the averages for each treatment. Cobblers were used at all three locations, where they were planted as soon as the weather and the soil were suitable.

The crop started off well at Marietta but the plants were soon attacked by a bacterial infection of undetermined origin that developed as a soft, black rot that destroyed all but the vascular tissue of the stems for a distance of about 2 inches where they were in contact with the soil (bacterial stalk rot). None of the wide variety of fungicides gave any appreciable control of the disease. This was the first time this type of infection had been observed to cause any appreciable loss in experimental spray plots in Ohio, but it has been seen at intervals since and many growers also have reported it, particularly on muck soil where the vines are unusually heavy and dry off slowly each morning. The disease was widespread over Ohio again in 1955 and the causal organism, a bacterium similar to **Erwinia carotovorus** has now been isolated. Bacterial stalk rot, late blight, and early blight completely defoliated the untreated check plots at Marietta.

Many of the fungicide formulations being used failed to control late blight and as a result much of the foliage was killed by mid-July. Dithane (treatments 21, 22, and 23) gave the best control of the disease complex, closely followed by Tribasic plus p.e.p.s. (treatment 9). Fungicide 1189, Crag 658, Cop-O-Zinc, and certain other Tribasic formulations also gave good results. Dithane D-14 plus $ZnSO_4$ gave a significantly better yield than 15 of the 20 other treatments used, and Tribasic plus p.e.p.s. was better than four other formulations. The other fungicides used were significantly better than the untreated check only. Dilan gave the best yield of the insecticides used, but the increase was not significant in any instance.

The Wooster experiment afforded little opportunity to grade the treatments used according to their fungicidal effectiveness, chiefly because of a lack of either early or late blight infection and the severe attack of "stalk-rot" mentioned in reference to the Marietta experiment. The yields of the differently sprayed plots were not significantly different one from the other in most instances and not all of them were significantly better than the untreated checks. Dithane, Methasan S, and Zerlate gave some of the best foliage scores and these same treatments, as well as copper cupferron, gave some of the best yields.

The situation at Willard (Celeryville) was unique for 1950 in that no late blight developed. However, Alternaria blight appeared early in the experimental block and became very severe before the end of the growing period. As a result it was possible to sort the fungicides included in this experiment rather closely on the basis of their ability to control Alternaria (early) blight on potato. An inspection of the data on defoliation (Willard in Table 39) indicates that Dithane D-14 plus $ZnSO_4$ and Methasan S gave the best foliage protection, closely followed by Dithane Z-78 (treatment 22)—the material that gave the largest yield of any used in the experiment. The contrast between Methasan S and Zerlate is interesting in view of the fact that both are zirams, but the tank-mix formulations gave far better control of early blight than did the wettable powder (Zerlate) in this instance, as it has in various other tests where the two have been compared.

On the basis of comparative yields only five treatments were significantly better than the others. These were Dithane Z-78, Dithane D-14 plus $ZnSO_4$, Methasan S, Methasan B, and Tribasic plus parathion. The performance of parathion was outstanding in this experiment where leafhoppers and aphids were numerous. Dilan also gave good results, and in the data representing average performance in all three experiments it gave a slightly better foliage score and yield than did parathion. Also, on the basis of average performance at all three locations, it should be noted that the Dithane formulations (treatments 21, 22, and 23) gave the best yields, closely followed by Tribasic plus p.e.p.s. and Methasan S. This latter treatment was tied with the Dithane formulations in the checking of defoliation by early and late blights where these diseases appeared. P.e.p.s. improved the performance of Tribasic and Zac-X6 but failed to do so with Dithane Z-78.

Katahdin potatoes, planted early in June, were used in a performance test involving 40 different fungicide or fungicide-insecticide formulations. The data relative to this experiment are given in Table 40. Early blight appeared comparatively soon in this field and came to be of medium severity before harvest. By September 1, late blight had caused considerable defoliation on some of the plots treated with fungicides incapable of checking the disease.

By September 10, when the checks showed 80 percent defoliation, the foliage condition was outstandingly good on the plots treated with zineb and maneb (treatments 20, 21, and 22). Several copper-containing formulations ranked second best, as in treatments 3, 5, 6, 7, 10, and 11. Methasan S was again comparatively good. Robertson Fungicide, Bordeaux, and C 5400 were tied in a third group. A number of Vancide and Zac (ziram modifications) formulations failed to give good control of either early or late blight in this test, as did 49-CS-43. All other treatments were more or less intermediate in their fungicidal effectiveness. The use of p.e.p.s. as an adhesive improved the performance of COC-S, but had little effect on Robertson Fungicide or Zac-X6.

An examination of the yield data in Table 40 indicates that most of the treatments used gave a significant increase over the untreated check plots. Exceptions were treatments 25, 32, 35, 38, 39, and 40. Some of the largest yields were again obtained with zineb and maneb (treatments 20, 21, and 22), with Methasan S giving very good results, as did Cop-O-Zinc. In fact, all of the fixed coppers, used at recommended strength, gave a good account of themselves in this experiment. The effect of decreasing Tribasic from a 4-100 to a 3-100 formulation was rather striking, as was halving the amount of Methasan B. This was one of the first instances in which Orthocide 406 (captan) was used in these Ohio tests and in a 2-100 formulation it gave an intermediate, or average, degree of disease control. Many of the organic formulations used gave a better yield than did Bordeaux mixture in this experiment, although the foliage condition was comparatively good on the plots treated with the latter. There was little to choose between the three insecticides used with COC-S, but parathion gave the best foliage condition and yield.

Some of the new fungicidal formulations submitted for trial in 1950 were further compared with zineb and Bordeaux in an experiment on early-planted Cobblers at Wooster. Late blight did not appear in the vicinity until after these plots were virtually mature, and as a result early blight was the only foliage disease of any consequence, and this was of only medium severity. Thus, the degree of sorting for fungicidal effectiveness was rather disappointing, with most of the yields failing to be significantly above the average for the untreated check plots. The data are presented in Table 41.

Zineb, in the form of Parzate, included as a standard comparison treatment, showed the best disease control (see defoliation data) in a scoring made on August 2, and also the highest yield at harvest. Methasan S ranked second in foliage condition and yield, again demonstrating its ability to control early blight. In fact, it did better than maneb (MnEDB) in this experiment. Orthocide 406 was again intermediate in performance, but did as well, or better, than Bordeaux. The ziram modification in the form of Vancides and Zac again failed to equal Methasan S (another ziram) in performance. The addition of p.e.p.s. to Zac-X6 resulted in some increase in effectiveness in this experiment.

Another experiment very similar to the one just discussed was arranged to study the effect of various adjuvants on the performance of several different fungicides. The data relative to these formulations are given in Table 42. These treatments were also applied to early-planted Cobblers where late blight was absent and early blight was of only medium severity. Zineb (treatments 13 and 14) was again above the average in foliage condition and yield but a few other formulations were approximately equal to it in performance.

One of the materials being studied in this experiment was the adhesive indicated here by the symbol "p.e.p.s." or polyethylene polysulfide. This material is a mild fungicide which also has adhesive properties. Its use in this instance with five different fungicides (Zac-X6, Methasan W, Parzate, Robertson Fungicide, and Vancide 51) gave little improvement in average foliage condition (last item in Table 42) but did result in an average increase in yield of 15 bushels per acre. Latex VL-600, another adhesive, did not noticeably improve the performance of Zac-X6 or Parzate. Halving the concentration of the Methasan formulations did not appreciably decrease their ability to control disease in this instance. The same was true of Robertson Fungicide. Several of the different combinations failed to give significant increases in yield over the untreated checks—a good indication that the disease complex was not a very important factor in regulating yield in this experiment.

It was in 1950 that the first serious effort was made to compare various fungicidal formulations in their ability to control foliage diseases of potato and tomato when applied in both high (regular) and low (concentrate) gallonages (a preliminary comparison was made in 1949). The data presented in Table 43 illustrate what happened when this was done in cooperation with a group of agricultural engineers from the U. S. Department of Agricultural Engineering Laboratory located at Toledo, Ohio. The commonly recommended formulas were applied at 160 gallons per acre and 300 p.s.i. with cone-pattern nozzles, and these formulations then were compared with others in a 4X concentration applied at 40 gallons per acre at 80 p.s.i. with flat, or fan-pattern, nozzles. Five organic fungicide (zineb and ziram) formulations and two fixed coppers (Tribasic and COC-S) were used in this preliminary study.

Early blight was comparatively severe in this planting of Cobblers at Wooster, and as a result the untreated check plots were completely defoliated at least 2 weeks before most of the treated plots were ready for harvest. Virtually all of the treatments had given about 50 percent control of the disease on August 2 (Table 41) and gave a significant increase in yield over the check plots at harvest. The organic fungicides gave slightly better results than the copper compounds in disease control, but for some unexplainable reason the tank-mix formulation of zineb failed to give its usual good control in either the X or 4X formulation.

However, the experiment was designed to compare regular and concentrate rates of application. The average percentages of defoliation and the yield data listed at the bottom of Table 43 indicate that there was little to choose between the two rates of water used, so far as foliage condition was concerned, but the 4X formulation did give the higher average yield. A breakdown of the results obtained with each fungicide shows that the concentrate, or 4X formulation, applied at 40 gallons per acre gave as good or better results than the regular procedure with five of the seven fungicides used in a comparison of yields, whereas the results were the same on the basis of foliage condition. However, differences were minor in every instance and well within the limits of experimental error, and the conclusion that the low-gallonage applications were equally as effective in disease control as those made in the usual manner seems justified.

Another planting of Cobbler potatoes, made somewhat later than is usually done with that variety, was sprayed with various fungicide-insecticide combinations all formulated in a 4X concentration and applied at 40 gallons per acre and 80 p.s.i. In addition, a copper-aerosol preparation was applied at 6 gallons per acre and 60 p.s.i. in a test of the feasibility of using such a formulation in the application of a fungicide. The data relative to this experiment are given in Table 44.

Late blight became established in the planting about half way through the growing period and this, together with an early blight infection of medium severity, acted to cause complete defoliation of the untreated check plots rather early in their growth cycle. As a result, all treatments gave a significant increase in yield over the check.

Liquid Parzate plus $ZnSO_4$, and COC-S, gave the best control of late blight, with COC-S keeping the foliage green longer into the fall than any other treatment. The copper aerosol, which contained copper naphthenate as the fungicidal agent, also did an excellent job of controlling late blight. The highly adhesive character of this aerosol formulation, the use of which resulted in the application of no more than half as much copper as was used in COC-S, probably accounted for the good results obtained with it in the presence of a rather severe infection of late blight.

The ziram-containing mixtures in the form of Methasan S, Zac-S, and Vancide 51 gave only mediocre control of late blight, and as a result the yields of the plots sprayed with those compounds were considerably below those obtained with the fixed coppers. Insects played a minor part in influencing foliage condition and yield in this experiment where late blight was severe, and as a result the variations between the plots treated with Dithane Z-78 and the different insecticides used with it were comparatively small. The Dilan-treated plots yielded slightly better than those treated with DDT, and both of these materials gave some improvement in foliage condition over that obtained with parathion. None of the differences were outside the range of experimental error, however.

Still another block of late-planted Cobblers was used in another experiment that involved variations in application practices. An air blast is frequently employed in the application of a concentrate spray formulation to act as a vehicle to carry the spray droplets from the sprayer to the point of deposition on, and in, the foliage mass. These blasts of air are usually of considerable volume and velocity and are commonly used to carry the spray material for a considerable distance, something like 30 to 40, or more, feet. However, in this instance, the spray nozzles were mounted in the air blast from the nozzles of an ordinary crop duster. Spray applications made in this way were then compared with and without the supplemental air blast to determine, if possible, the desirability of using air to give better penetration of the foliage complex by the spray particles, which naturally had less carrying potential in low-pressure, low-volume application than with larger volume, higher pressure spraying. The data relative to this experiment, in which two fungicides and two insecticides were used, are given in Table 45.

The results obtained were somewhat inconclusive, but the use of the small volume, comparatively low-velocity blast used in this experiment did not add anything to the effectiveness of the spray formulations being used. In fact, the droplets of spray material showed some tendency to be grouped near the center of the air blast, giving a somewhat streaked appearance to the spray pattern on the plant foliage. This was, of course, due to the fact that it was difficult to so mount the liquid nozzles in the outlet of the duster nozzle so that an even distribution of the droplets through the cross section of the air blast was obtained. Parathion and DDT gave similar results in insect control, but Tribasic seemed to be somewhat more adaptable to concentrate application than was Zerlate in this experiment.

A number of different insecticides were applied to potatoes in an experiment conducted at Wooster. The data are summarized in Table 46. DDT, methoxychlor, Rhothane, Dilan, Q-137, and parathion gave excellent control of leafhoppers and flea beetles. Chlordane, lindane, aldrin, and toxaphene gave good control of flea beetles but relatively poor control of leafhoppers. Parathion, lindane, and Pestox effectively controlled aphids. The application of lindane to the foliage imparted an off-flavor to the tubers.

1951

The growing season in Ohio was comparatively dry and warm in 1951, and as a result late blight was virtually absent over most of the area, and early blight of potatoes was of moderate importance as a yield-regulating factor in most of the fields where experiments designed to compare the fungicidal effectiveness of different spray formulations were located. As a result the data obtained were not nearly as definitive as those obtained in 1950 (36).

It has been the custom of the authors for the past several years to use an identical list of treatments on potatoes at Marietta, Wooster, and Willard. This practice was continued with a group of 25 treatments in 1951. The data relative to yield and foliage condition near the end of the growing season at each location are given in Table 47. Average values of these two measures of fungicide-insecticide performance are also given for each treatment.

Early blight was of only medium severity at Wooster. It was somewhat more destructive at Marietta. At Willard it appeared early during the growth period and became very severe before the end of the season, defoliating the untreated checks virtually 100 percent about 2 weeks before normal maturity.

The usual practice of using several insecticides with a single fungicide (Tribasic in this instance) and several fungicides all with the same insecticide (DDT) was followed. In the averages of yields and foliage conditions at the three locations there was little to choose between the eight insecticidal formulations. Their comparative performance in controlling flea beetles was determined by counting the feeding punctures of the adults in a sample of 10 leaflets taken at random from each plot. DDT and Dilan gave the best control of this insect with an average of 19.2 and 17.2 holes per leaflet, respectively. Parathion, Compound 4049 (W.P.), Compound 4049 (Emul.), Systox, Pestox, and Metacide gave a lesser degree of control with 40.4, 67.8, 38.0, 79.4, 40.0, and 47.4 holes per leaflet in the order named. The untreated check plots averaged 122 holes per leaflet. Metacide ranked at the top of the group in both yield and foliage, but by such a small margin over most of the other compounds that little significance can be attached to the ranking. This similarity in the performance of comparatively effective insecticides, all applied to small plots in a pattern of random distribution, frequently occurs on potatoes, as has been mentioned before, because of the overlapping influence of one control pattern on another.

There was a somewhat wider spread in fungicide performance in the control of early blight, as is indicated by the data on foliage condition, but again there were few yield differences large enough to indicate significance. Dithane D-14 plus $ZnSO_4$ was best in early blight control, but it was closely followed in these experiments by three other tank-mix formulations, all of which contained at least some sodium dimethyl dithiocarbamate to which $ZnSO_4$ was added (treatments 18, 19, and 21). These four tank-mix formulations were also best in average yields. Maneb as a wettable powder (treatment 24) ranked slightly below these zinc-containing compounds, as did the tank-mix formulation that contained manganese (treatment 22). This was also true of ziram as a wettable powder (Zerlate in treatment 17).

Among the copper-containing formulations, copper cupferron and Cop-O-Zinc gave somewhat better results than did Tribasic, Crag 658, or Robertson Fungicide. The addition of p.e.p.s. to Tribasic improved its performance somewhat, with an average increase in yield at the three locations of 28 bushels per acre and a decrease in defoliation of 10 percent.

In an extension of treatments (not listed) at Willard the addition of p.e.p.s. to COC-S definitely increased the control of early blight without much increase in yield. Cop-O-Zinc, which contained only 5 percent of zinc, gave almost identical results at Wooster and Willard with that which contained 11 percent.

Another experiment at Wooster in 1951 was utilized to give a comparison between different formulations of each of several different fungicides. The data relative to this test are given in Table 48. A considerable portion of the experiment was devoted to a comparison of wettable powder, slurry, and tank-mix formulations of some of the "dimethyl" and "ethylene bis" dithiocarbamates. In general, it may be said that the tank-mix formulations, prepared in the field by adding solubilized zinc sulfate to the liquid sodium salt of the carbamate, gave slightly better disease control than did the wettable powders prepared by the manufacturer. This general statement will be further substantiated by data to be presented later.

Methasan (ziram) was compared as a wettable powder, a slurry, and a tank-mix formulation. The tank-mix preparation gave the best yield in this experiment, with the slurry (Methasan S) intermediate in yield but first in disease control. Zac (a ziram-cyclohexylamine complex) was also used in three formulations. In this instance the tank-mix preparation was best in both yield and disease control. Vancide 51 (a ziram-mercaptobenzothiazole mixture) was used in various formulations. The tank-mix preparation was again better than the wettable powder, but by a narrow margin (treatments 9 and 11). Manzate (maneb) and Dithane Z-78 (zineb) as wettable powders were compared with their respective counterparts in tank-mix formulations, with the score slightly in favor of the wettable powders in this experiment.

Robertson Fungicide (copper and cuprous oxide) and the Calumet and Hecla cuprous-cupric oxide complex (CHCO) were each formulated with a suspending agent (F-1060) and an adhesive to determine, if possible, the influence of these adjuvants on the performance of the cuprous oxides. The data indicate comparatively little benefit from the use of the suspending and adhesive agents, there being a slight improvement with Robertson Fungicide and none with CHCO.

COC-S was used alone and with the addition of $ZnSO_4$ and of p.e.p.s. All three formulations were essentially similar in performance, with COC-S used alone giving slightly the higher yield. Copper Hydrate and a flake copper preparation by Phelps-Dodge did at least as well as the other copper compounds used in this experiment. The test was not indicative of the comparative potentialities of the copper-containing fungicides used, since late blight did not appear and early blight was of medium severity and appeared comparatively late in the growth of the plants.

Some of the compounds and formulations applied to Cobbler potatoes earlier in the season (Tables 47 and 48) were compared on later-planted Katahdin potatoes. The data relative to this experiment are given in Table 49. Late blight did appear in this planting and early blight was very destructive, defoliating the untreated check plants about 3 weeks ahead of normal maturity and causing a considerable loss of foliage in some of the plots treated with formulations incapable of holding that disease (early blight) in check.

In starting at the top of the list of treatments and moving downward, it is apparent that the addition of p.e.p.s. to Tribasic materially improved its ability to control early blight. On the other hand, the addition of a conditioning agent to COC-S actually interfered with its effectiveness. The cuprous oxides (Robertson Fungicide and CHCO) were similar in disease control and yield. Copper cupferron was comparable with the rest of the fixed coppers included in the experiment. Cop-O-Zinc gave excellent control of early blight but the yield was not correspondingly large. Crag 1217, a specially formulated chromate, was not as effective in disease control as was the more standard product known as Crag 658.

Zerlate (treatment 13) represents the first of the dithiocarbamates included in this experiment. Methasan S (a slurry preparation of ziram) gave considerably better control of early blight than did Zerlate, and was even better than the tank-mix formulations of ziram (treatments 15, 16, and 19). Tank-mix zineb (treatment 17) was comparable with the wettable powder (Dithane Z-78). Tank-mix maneb (treatment 18) gave a high yield in spite of a considerably poorer control of early blight than the wettable powder in the form of Manzate. Baycar and OS 377 (two new fungicides under test) failed to give any appreciable control of the disease and as a result the yields were little better than those of the untreated check plots. Bordeaux was comparable with several of the fixed coppers in its performance in this experiment.

Treatments 1, 17, 24, 25, 26, and 27 formed a special grouping set up to study the comparative effect of Bordeaux mixture, zineb, and DDT on the chipping quality of potatoes. These data will be discussed later in another publication on that subject.

In another experiment at Wooster in 1951, Cobbler potatoes were sprayed with 4 copper-containing fungicides and 4 organic compounds, all applied in X and 4X concentrations at 160 and 40 gallons per acre, respectively. In addition, p.e.p.s. was added to each of the 4 copper compounds and these mixtures were applied at 160 gallons per acre. The data relative to this experiment are given in Table 50.

The yield and foliage condition averages (lower portion of Table 50) for the 8 different fungicides applied in the X and 4X formulations were approximately the same, with both disease control and yield slightly favoring the 4X formulations applied at 40 gallons per acre. The two concentrations were very similar in performance for the fixed copper compounds, as they were with the organic fungicides. Because of the similarity of both foliage condition (degree of disease control) and the resulting yields, one may conclude that the two methods of spray application were of approximately equal effectiveness. The addition of p.e.p.s. to "X" concentrations of the fixed copper compounds resulted in a slight average increase in disease control (57.8 percent defoliation with p.e.p.s. and 59.8 percent without) and an average increase in yield of 8 bushels per acre. Whether this would justify, on a cost basis, the use of p.e.p.s. as an adhesive is doubtful.

In the three-location series at Willard, 11 extra treatments were included to afford a comparison between regular and concentrate formulations of some of the fungicide-insecticide combinations used at the three locations. There these extra "4X" treatments were numbered from 30 to 40, inclusive, and are listed in Table 51 on the same line with their respective counterparts in the usual, or "X" formulation.

The 4X formulations of Tribasic plus 4 different insecticides, applied at 40 gallons per acre, all gave somewhat better control of disease and better yields than did the corresponding "X" formulations at 160 gallons per acre. Both Cop-O-Zinc and Crag 658 gave the best disease control in the 4X formulations. There were no differences in disease control between the 4X and X preparations of the four organics, Zerlate, Vancide 51, Manzate, and Dithane Z-78, and the yields were virtually equal.

In an average of all 11 treatments the 4X formulations at 40 gallons per acre gave better disease control (early blight) and a slightly better yield than did the usual "X" concentrations in which 160 gallons were applied per acre. Thus, so far as this particular experiment is concerned, the use of "concentrate" spray formulations, applied at one-fourth the gallonage commonly recommended, gave as good control of early blight on potatoes as the usual spraying procedure. Yields also were comparable.

This study of "concentrate" spraying of potatoes was carried one step further in 1951 when two fungicides, a fixed copper (COC-S) and an organic fungicide (Manzate), were formulated each with two insecticides and applied in the same X and 4X concentrations. The results are presented in Table 52, where data on early blight, flea beetle damage, and yield are given.

The averages for all four insecticide-fungicide combinations indicate that there was little difference in the degree of disease and insect control obtained with the two types of spray applications. The 4X applications made at 40 gallons per acre gave slightly higher yields, although disease and insect control were not quite as good as with 160 gallons of the "X" or regular concentration. The data on treatment averages indicate that there was little to choose between COC-S and Manzate, and between the two insecticides, with respect to their suitability for use in concentrate applications.

1952

The spray experiments on the control of the foliage diseases of potatoes using a variety of fungicides, fungicide-adjuvant formulations, and concentrate preparations designed for low-pressure, low-volume studies were carried on in 1952 as in previous years (39, 40). The weather in 1952 was not especially conducive to the development of early and late blights of potato. Late blight failed to appear in any experimental block, and as a result there was less than the usual opportunity to classify the different chemicals and formulations according to their ability to control foliage diseases of potato.

April started the growing season off by being approximately normal in temperature and rainfall. May was slightly deficient in both of these factors. There was only 0.15 inch of rainfall during the 4-week period from May 26 to June 22. As a result early blight, which usually appears by late June in Ohio, was scarce in July. July was warmer than usual and deficient in rainfall over much of Ohio, being close to normal at Wooster, however. The same was true of August with respect to temperature and rainfall. September was more moist and as a result early blight did get a start on potatoes at Wooster, but in most instances it appeared too late to have much effect on yields.

The three-location experiment on potatoes (Marietta, Wooster, and Willard) was repeated in 1952. The data relative to the three sites are given in Table 53. Early blight caused only moderate defoliation of the untreated check plots at Marietta and Wooster, but did become quite severe at Willard before the end of the growing season on the Cobbler potatoes used at all three locations in this experiment.

Parzate plus p.e.p.s. and Zerlate plus p.e.p.s. gave the best average yields in this experiment and were among the top six treatments in terms of disease control on the foliage. Parzate plus DDT without p.e.p.s. (treatment 5) also ranked high in both yield and disease control, but p.e.p.s. definitely improved the performance of Zerlate (treatment 2). This adhesive also increased the effectiveness of Tribasic, the only other fungicide with which it was used (treatments 12 and 13). SDD plus $ZnSO_4$, a tank-mix formulation of ziram, gave somewhat better control of defoliation than did Zerlate (the wettable powder formulation), accompanied by an average increase in yield of 19 bushels per acre over Zerlate. Maneb, in the form of Manzate, failed in this three-location experiment to equal the performance of zineb in either disease control or yield, and the tank-mix formulation (treatment 9) was even less effective. Tribasic was improved slightly in disease control by the use of p.e.p.s. and Vancide Sticker, and definitely in terms of yield. The poorest response, in terms of both yield and disease control was obtained with two experimental fungicides, listed as XP-63 and XP-90 (See Materials Key), both of which were somewhat phytotoxic on potatoes.

Several different insecticides were formulated with Parzate as the fungicide (treatments 5, 21, 22, 23, 24, and 25 in Table 53). All of these formulations gave above average foliage readings and somewhat better than average yields. Dieldrin gave the best foliage score and DDT the highest yield. Systox was comparable with the other insecticides used in overall performance. There was little or nothing to choose between the wettable powder and emulsifiable formulations of malathion.

Ten additional treatments were used in the Wooster experiment of Table 53. These included among others, Manzate plus p.e.p.s., COC-S, COC-S plus p.e.p.s., and Cop-O-Zinc. In these formulations p.e.p.s. added to Manzate improved the foliage condition slightly but failed to increase the yield of potatoes. With COC-S it increased both disease control and yield. When added to 5 fungicidal formulations p.e.p.s. gave an average increase in yield of 6 bushels per acre and a defoliation decrease of 4 percent over the same 5 fungicides used alone. Foliage condition was improved in four of the five instances and yields were increased in the same four formulations. Cop-O-Zinc was no better than Tribasic in foliage score and was slightly poorer in yield. A mixture of COC-S and Vancide 995 was somewhat phytotoxic.

In another experiment, 35 treatments were applied to Cobbler potatoes at Wooster in 1952. The relative effectiveness of wettable powder and tank-mix formulations of some of the dithiocarbamate fungicides, of three mercurials, of three antibiotics, and of various copper formulations in the control of foliage diseases were studied. DDT was used with all treatments for insect control. The data relative to experiment are given in Table 54.

The best foliage near the end of the growth period of this planting was to be found on those plots treated with SDD (treatments 3, 4, and 14). This speaks well for the ability of this tank-mix formulation of ziram to check early blight—the only foliage disease of any consequence on these potatoes. Treatment 4 (a mixture of SDD and nabam) gave the highest yield of the experiment, followed by other ziram-containing formulations in treatments 19, 14, and 3. All of these gave better results than ziram as a wettable powder (Zerlate) in treatment 1. There was little to choose between zineb as a wettable powder (Dithane Z-78) and the tank-mix formulation of Dithane D-14 plus $ZnSO_4$. Replacing part of the $ZnSO_4$ with $CuSO_4$, or with three sulfates (treatment 9), gave results that were little different from treatment 6. The combination of four sulfates in the latter instance was used to test the possibility of a nutritional response on the part of the potato plants, but they appeared to be little different from those that received only $ZnSO_4$. Fermate and Dithane D-14 plus $FeSO_4$ gave similar results, and both treatments were less effective in controlling early blight than were most of the zinc-containing carbamates. Maneb as a wettable powder (Manzate) gave slightly better results than did Dithane D-14 plus $MnSO_4$ or SDD plus $MnSO_4$. Vancide 51 plus $ZnSO_4$ gave definitely better results than any of the wettable powder formulations of Vancide. Sporcop, a formulation of copper naphthenate formulated in SV-100 spray oil, was somewhat phytotoxic, and the mercurials represented by treatments 24, 25, and 26 failed to satisfactorily control early blight. This was likewise true of the three antibiotics Thiolutin, Terramycin, and Rimocidin.

The data of this experiment indicate that tank-mix formulations of ziram are better able to control early blight on potato foliage than are the wettable powder preparations and that the reverse is true for maneb, whereas there is little to choose between the two types of formulation with zineb.

In a further test of the efficacy of p.e.p.s. as an adhesive for row-crop fungicides, a planting of Katahdin potatoes was sprayed with two fixed coppers and two organic compounds, formulated with and without p.e.p.s. In addition, several different formulations of zineb and maneb were included. The data relative to the experiment are given in Table 55. With comparatively warm, dry weather in late summer at Wooster in 1952 no late blight developed in the area, and even early blight was late in appearing. It did become rather active in late September, as is indicated by the fact that the untreated check plots showed 92 percent defoliation by October 6.

Zineb (wettable powder) and nabam + $ZnSO_4$ (tank-mix formulation) were very similar in performance, with the data favoring the wettable powder formulation slightly. In a similar comparison of maneb formulations (treatments 3 and 6) the difference was again in favor of the manufacturer's product.

The fixed coppers gave less control of early blight than did zineb and maneb, and as a result the yields were less also.

In a comparison of no adhesive versus p.e.p.s., the average defoliation values for all 4 fungicides were 55.5 percent and 47.3 percent, respectively, whereas the comparative yields were a tie at 399 bushels per acre. The fixed coppers were improved more in performance by the addition of the adhesive than were the two organic fungicides; in fact, the latter showed almost no change in the defoliation score and even a slight decrease in yield when p.e.p.s. was added. This difference in response to the use of adhesives has been rather general throughout a series of tests during the past few years on potatoes and tomatoes in Ohio, with the copper fungicides often showing a considerable improvement in disease control and the organics a much smaller response from the addition of an adhesive. This difference may be associated with the fact that the copper compounds as a group are more stable both chemically and physically than are the organic materials, and thus give more return in terms of better disease control when an adhesive is added.

During the past few years there has been considerable speculation concerning the possible effect of some of the new organic fungicides, particularly zineb, on the cooking and chipping quality of potatoes. Miscellaneous samples collected during the last 2 or 3 years from plots sprayed with copper-containing fungicides and those sprayed with zineb, maneb, and ziram formulations have failed to show any very consistent differences in specific gravity of the tubers, or in general appearance and taste of the chips made from them. However, there is the possibility that the tubers produced on vines sprayed with zineb and DDT, both of which tend to delay the maturity of the potato plant beyond the time when those that were formerly sprayed with Bordeaux mixture plus calcium arsenate could be expected to become mature and die, might be less mature and thus of lower specific gravity than those treated with Bordeaux. Consequently, an experiment was designed to determine, if possible, what and how great the differences might be over a period of years and under different environmental conditions. Some of the data relative to the first of these tests are presented in Table 56.

The treatments included an untreated check, Bordeaux only, Bordeaux plus DDT (to check on the effect of the DDT on maturity), zineb (Dithane Z-78) plus DDT used throughout the season, and finally a combination treatment in which the Dithane plus DDT formulation was used only part way through the spray period after which a change was made to Bordeaux. This last treatment was designed to conform with the practice of some growers in their change to Bordeaux near harvest time to mature the vines more quickly and thus have the tubers less subject to harvest bruises and to decay resulting from Fusarium and late blight infections. Also, since they are somewhat more mature on a given date, the tubers should be of a somewhat higher specific gravity, if all of these suppositions concerning the effect of spray practices on tuber quality are valid.

In the data of Table 56 the correlation between vine condition (percent of foliage dead) and yield is quite obvious, especially between treatments 1 and 3. The gradual increase in yield as harvest was delayed is also interesting, with the increase being least with the untreated checks, which were most nearly defoliated at the time of the first digging, intermediate with Bordeaux, and most on the least mature, or Dithane-treated plots. A striking similarity exists in the average specific gravity values for the tubers from the differently treated plots. All were high and not significantly different one from another. If the specific gravity value is a reliable index of chipping quality, then there was little to choose between Dithane and Bordeaux, and Bordeaux with and without DDT. Furthermore, a considerable sacrifice in yield was made by using the copper-containing rather than the organic spray material. Additional data on this type of experimentation will be presented for 1953, 1954, and 1955 in this bulletin, and this will be followed later by other data in another publication on how spray practices have affected chipping quality as determined by the Food Processing Laboratory of the Horticultural Department at Ohio State University.

The experiments begun previously on low-pressure, low-volume (concentrate) spraying of potatoes were continued in 1952 and some of the data relative to these are presented in Table 57. The rate of application varied from 10 to 160 gallons per acre, whereas only two pump pressures were used—56 pounds per square inch with a flat spray pattern and 50 pounds with a hollow-cone nozzle. Different numbers of nozzles were used in spraying a pair of rows in a swath width of 5½ feet. The forward speed of the tractor was varied to give the rate of application desired with the number of nozzles being used. Early blight did not appear in this experimental plot until comparatively late in the growth period, but then developed rapidly to defoliate the untreated check plots by September 20. At that time there was comparatively little difference in the appearance of the differently sprayed plots, and the yields varied but little at harvest about 2 weeks later, with the possible exception of those being sprayed at 10 gallons per acre with only one flat-pattern nozzle on a pair of rows (treatment 6). In this instance the degree of foliage coverage was apparently too poor to afford good disease control. Otherwise, there was little to choose between 20 and 160 gallons per acre with two to four nozzles per row. Neither was there much difference when one to four nozzles were used to apply 40 gallons per acre in a flat spray pattern (treatments 7 to 10, inclusive). In the hollow-cone series one nozzle used to apply 40 gallons per acre did not do as well as 2 and 3, but for some reason, which was not apparent, 10 gallons per acre applied with one nozzle (treatment 15) did as well as two at 20 and 40 gallons per acre. Perhaps the most obvious thing concerning the experiment as a whole was the similarity, or uniformity, of the results obtained with the different rates of application, both in terms of disease control and yield. However, it is possible that variations might have been greater if more disease had appeared and it had become more severe earlier in the growth period of the potatoes.

An experiment similar to the one just described was carried through the season on a planting of Russet potatoes. The data are presented in Table 57. Disease was comparatively scarce, and although most of the treated plots gave a significant increase in yield over the unsprayed checks there was no significant difference between the yields of the differently sprayed plots. The data are presented chiefly to emphasize again how similar the results obtained may be when potatoes are sprayed with wide variations in gallonage (20 to 160 gallons per acre) and in the concentration of the formulations being applied (2 to 16 pounds of Manzate in each 100 gallons of water).

1953

During the last three summers (1951, 1952, and 1953) the weather at Wooster, and at many other points in Ohio, has been too dry and warm to be favorable for the development of the foliage disease of vegetables. Even early blight of potato and tomato, which seldom fails to appear in epidemic form at some point in the state, was very scarce at Wooster in 1953. It was somewhat more plentiful at Willard (Celeryville) and comparatively severe at Marietta. Late blight was absent at all three locations. As a result of this comparative scarcity of early blight and non-appearance of late blight, experiments designed to compare the effectiveness of various fungicide formulations in disease control were not "fraught with decisiveness".

The weather of April and May at Wooster was fairly normal, with April only slightly cooler and drier than usual and May somewhat warmer and wetter. In June the rainfall was less than half of normal. July was only slightly cooler and drier than usual, but August had less than half the normal rainfall. This deficiency was followed by a warm and extremely dry September, when the rainfall was only 0.33 inches, or about one-seventh the normal amount. This dry period was also very warm, with an average temperature excess of 1.5 degrees per day for the month. There was a 10-day period from August 26 to September 4 when the maximum temperature was 93° F., or above.

The experimental work on potato and tomato spraying in 1953 was concerned with comparisons of fungicides for disease control, the application of specific materials with a hydraulic sprayer at different pressures and gallonages (concentrations), and other tests with large air-blast equipment involving studies on disease control and distribution patterns.

The three-location series, made up of 25 different treatments, was conducted on potatoes at Marietta, Wooster, and Willard, as has been done for the past several years (40, 41). The data for this triple comparison are listed in Table 58. Early blight became severe in the experimental planting at Marietta about 4 weeks before the normal maturity date, and was responsible for the almost complete defoliation of the untreated check plots as well as some of those treated with the less effective fungicides, about 2 weeks before harvest. Four insecticides and combinations of two of these were used with Dithane Z-78 in 1953, and 15 fungicides plus some special formulations were applied with DDT as an insecticide.

There had been some indication during the past 2 or 3 years that DDT was not giving good control of flea beetles and in 1953 comparisons were made between a mixture of dieldrin and DDT applied in each application and DDT and dieldrin used separately in an alternate schedule of applications. This grouping accounts for the first four formulations listed in Table 58, or treatments 2 to 5, inclusive. At Marietta the mixture of the two insecticides and the alternating schedule both gave a better foliage score than either compound used alone, but there was no appreciable difference in yield. At Wooster there was little, if any, difference in foliage condition between the four treatments, but the variants gave somewhat better yields than the single compounds. At Willard there was little difference in either the degree of defoliation or yield. As a result, the average values for the three locations showed a slight advantage for the mixture of DDT and dieldrin, and the alternating schedule, in both foliage condition and yield over either of the insecticides used alone. So far as aldrin and Strobane were concerned, neither equalled DDT or dieldrin in the average condition of the foliage or in average yield at the three different sites.

In a comparison of some of the different fungicides and fungicidal formulations included in this experiment, Lo-738 was slightly less effective in disease (early blight) control than Dithane Z-78 (treatment 4) at Marietta and Willard, and in the three-location averages. The differences were small, however. T-M ziram ranked somewhat below Zerlate at all three sites in both foliage condition and yield. SDD plus $ZnSO_4$ however, was somewhat better than either (treatment 11 versus 9 and 10, respectively). The inclusion of K-704 (an adhesive) with the tank-mix formulation (treatment 12 versus 11) contributed nothing to the latter. Maneb as a wettable powder (Manzate in treatment 13) gave slightly better disease control and a higher yield at all three locations than did the tank-mix formulation of Dithane D-14 plus $MnSO_4$. Manzate was very similar to Dithane Z-78 (treatment 13 versus 4) in both yield and foliage condition. Special formulations of B-160 were somewhat less effective in disease control and gave lower yields than did Dithane Z-78. This was also true of Al-119 and FF-10. The former was somewhat phytotoxic. The addition of two different adhesives (K-704 and p.e.p.s.) in treatments 20 and 21, respectively, did not appreciably improve the performance of Tribasic used alone (treatment

19), nor were Cop-O-Zinc or Cop-O-Manganese much different from Tribasic. Copper naphthenate and Cunilate 2472 were somewhat lower in effectiveness at Marietta and Wooster than the other copper formulations that were included in the experimental series.

Several old and new fungicidal formulations were compared on early-planted Cobbler potatoes at Wooster. The data for this experiment are given in Table 59. There was no late blight, and early blight caused only a medium degree of defoliation and reduction in yield. Flea beetle damage was severe in these plots where DDT failed to check them, and as a result this insect was responsible for a considerable reduction in yield. In fact, it was necessary to spray with two "blanket" applications of dieldrin about 10 days apart in mid-season to reduce the flea beetle population sufficiently to obtain any data on fungicide performance. In addition to this outbreak of flea beetles, a lack of soil moisture during the summer was a limiting factor in yield.

In spite of all these handicaps, all treatments gave a significant increase in yield over the untreated check plots. The best yield was obtained with a spray-tank mixture of SDD plus $ZnSO_4$. This was closely followed by the same formulation plus a polyacrylate adhesive (K-704). The use of the ziram formulations as a group actually gave a better foliage condition and a higher yield in this experiment than did the zineb and the maneb formulations. Zerlate was slightly inferior to SDD plus $ZnSO_4$. Dithane Z-78 and Dithane D-14 plus $ZnSO_4$ were similar in foliage condition and in yield. Manzate and Dithane D-14 plus $MnSO_4$ were identical in foliage condition but Manzate gave the better yield. The copper carbamate (He-177) was approximately equal to the zinc (Z-78) and manganese (Manzate) carbamates in the control of early blight. B-622, a newcomer in the ranks of experimental fungicides, was not very different in performance from many of the other formulations included in this experiment. A special copper naphthenate formulation (treatment 17) gave a fair degree of disease control but was sufficiently phytotoxic to reduce the yield slightly. Al-119 was also somewhat injurious to the potato foliage.

Several new fungicide formulations (see Materials Key) were compared in a planting of Cobbler potatoes at Wooster in 1953. The foliage and yield data are given in Table 60. Again disease was scarce because of the hot, dry weather in June and July. As a result the yield was only about half the normal expectancy and defoliation was not severe, even in the untreated checks. On July 24, or about 2 weeks before the plot was harvested, the defoliation had reached only 65 percent. In addition, flea beetle damage was severe. The yields of all treated plots were significantly above that of the check, with the exception of treatment 1 (Al-118) which was sufficiently phytotoxic to reduce the yield somewhat. Leaving out treatment 1, all others were very similar in yield and in foliage condition. Thus, the opportunity to classify this series of formulations on the basis of their ability to control either early or late blight did not materialize in this experiment. The series was repeated on Katahdin potatoes later in the season with even smaller differences in yield and foliage condition, even though there was a higher incidence of early blight. Those data are not presented here.

In another comparative test on Katahdin potatoes at Wooster, several different adhesives were added to Tribasic, and a polyacrylate type of adhesive was formulated with four different fungicides. Foliage diseases were scarce but flea beetle damage was severe. A critical lack of soil moisture following the setting of the tubers kept them small and yields were again much lower than usual for Wooster. Early blight had caused so little defoliation of the untreated check about 3 weeks before harvest that two of the treatments were not given an opportunity to produce a yield significantly above the check, even with a difference of only 12 bushels required for significance. Maneb (Manzate) in a 2-100 formula gave the best yield but one that was not significantly better than that produced by most of the other treatments in the experiment. Manzate 1½-100 without an adhesive agent was considerably poorer in yield and in foliage condition than the same formula to which an adhesive was added. The performance of Tribasic (4-100) was improved somewhat in every instance by the addition of an adhesive, but the yield increases were not significant and the improvements in the foliage score were small. The K-704 adhesive also improved the performance of the two cuprous oxides with which it was used. In an average of all four fungicides with which this material was used it increased the average yield by 9 bushels per acre and reduced the percentage of dead foliage from 43 to 38 percent. These data are given in Table 61.

There is a possibility that certain mixtures of insecticides and fungicides are physically and/or chemically incompatible. Therefore, an emulsifiable concentrate and a wettable powder formulation of DDT were used with a wettable powder and a tank-mix formulation of ziram. Calcium arsenate and DDT were used with Manzate. The list of formulations used, and the foliage and yield data obtained are given in Table 62. Katahdin potatoes were used for the experiment. The weather was comparatively hot and dry for Wooster and as a result yields were comparatively low. Early blight was of mild to medium severity and appeared late in the season. Flea beetle damage was rather severe but less than in many of the experimental plots at Wooster in 1953. All treated plots yielded significantly more than the untreated checks, but showed no significant differences among themselves. DDT (W.P.) gave a slightly better foliage condition than emulsifiable DDT when both formulations were used with Zerlate, but the yields were the same. The wettable powder formulation of DDT was also slightly better with the tank-mix formulation of ziram than was the emulsifiable DDT (treatments 4 and 5, respectively), but again the differences were small in both foliage condition and yield. The T-M ziram was inferior to Zerlate or the spray-tank mixture of SDD plus $ZnSO_4$ so far as foliage condition was concerned. It had been reported that calcium arsenate should not be used with Manzate because of some degree of incompatibility. The foliage score with this mixture was not as good as with Manzate plus DDT emulsion, but the yields were similar. Since a mixture of calcium arsenate and Manzate also gave comparatively good results in an experiment on tomatoes, it seems likely that any possible incompatibility was of minor degree. Furthermore, the results obtained in this experiment indicate that the emulsifiable form of DDT may be used with a wettable powder formulation of a fungicide such as Zerlate with little chance of plant injury.

The experiment started in 1952 to test the influence of spray schedule variations on the yield and chipping quality of potatoes was continued in 1953. The data relative to this investigation are given in Table 63. Here again any possible differences between foliage conditions and yields were held at a minimum by a scarcity of foliage diseases and a lack of sufficient soil moisture for good growth. Bordeaux mixture failed to give a significant increase in yield over the untreated check, even though the foliage was in considerably better condition at the end of the season on the sprayed than the untreated plots. This lack of yield increase may have been due to an unfavorable physiological effect of the Bordeaux on the potato plants (44), since an actual depression in yield occurred in 1954 during an even drier summer and will be discussed later in connection with a similar experiment in that year. When DDT was used with Bordeaux, there was some improvement in foliage condition and a slight increase in yield. Dithane D-14 plus $ZnSO_4$ plus DDT (treatment 3) gave the best control of insects and disease and the best yield of the four spray formulations. When DDT was dropped from the Dithane formula in mid-season, flea beetles became severe enough to account for a lower foliage score and a somewhat lower yield.

Again, as in 1952, there was no appreciable difference in the specific gravity values of the tubers from the differently treated plots, thus making it seem even more unlikely than before that the type of foliage spray used has any very marked influence on the specific gravity of the tubers, and in that respect on chipping quality.

The experimental work relative to the use of "concentrate" spray applications for disease and insect control was continued in 1953, in cooperation with the U. S. Department of Agricultural Engineering Laboratory at Toledo. The data of Table 64 represent the results obtained in a series of volume and pressure variations in spray applications on Cobbler potatoes at Wooster. These plants were subjected to a heavy infestation of flea beetles, to no late blight, and to only a medium infection of early blight.

The rate of application (volume) was varied from 10 gallons per acre of a 16X formulation to 160 gallons of an "X" formulation and with pressure variations from 20 to 300 p.s.i., with the higher pressures being used with the higher gallonages. Since foliage diseases were scarce, and although flea beetles were numerous, there was comparatively little difference in foliage condition and the resulting yields within the whole range of pressure-volume combinations. All yields were low, but all of those from sprayed plots were above those of the untreated checks. The best foliage condition, throughout the latter part of the growth period, occurred in the plots treated at 80 gallons per acre with a 2X concentration applied at 200 p.s.i. with a flat spray pattern (treatments 3 and 15). There was little to choose between the treatments applied at 20 to 80 gallons per acre with a pressure of 60 p.s.i., nor were the results much different from those obtained with the higher gallonages at higher pressures.

It should be noted that the foliage condition was comparatively poor, and that the yield was significantly lower than with most of the other treatments when a 16X concentration was applied at 10 gallons per acre with only one nozzle per pair of rows (treatment 7). The application of a 4X formulation at 40 gallons per acre and 20 p.s.i. (treatment 10) also gave a somewhat lower yield than the same gallonage applied at the higher pressures of 40, 60, 80, and 100 p.s.i. On the other hand, 15 gallons per acre at 60 p.s.i. was no different from many of the other combinations used in the experiment. Neither was there much to choose performance-wise between the use of flat-pattern and hollow-cone nozzles. Thus, the overall picture indicates that good disease and insect control should be obtained under normal conditions with formulations as concentrated as 5X or 4X applied at 35 to 40 gallons per acre, respectively, at pressures as low as 60 p.s.i., using nozzles designed to produce either a fan-shaped or a hollow-cone pattern.

Several of the same pressure-volume combinations included in the previous series were used to spray a planting of later-planted Katahdin potatoes. The data on foliage condition and yield for this experiment are given in Table 65. Early blight caused more defoliation in this planting and the yield variations between the differently treated plots were somewhat greater than with the Cobblers of the previous experiment, even though a deficiency of soil moisture did hold tuber production to a comparatively low yield. Only nozzles delivering a flat, fan-shaped spray pattern were used, and the pressure and volume variations were not as great as in the previous experiment.

There was no significant difference in the yields obtained from applications made at 20, 40, 60, and 80 gallons per acre at 80 p.s.i. There was, however, some bettering of the foliage condition (disease control) with an increase in gallonage. Neither was there any appreciable difference in yield when 40-gallon per acre applications were made at 20, 40, 60, and 80 p.s.i., although the use of 20 p.s.i. did result in a considerably poorer foliage condition than the use of higher pressures. When 80 gallons per acre were applied at 40, 60, 80, and 100 p.s.i., there was again very little difference in yield or foliage condition with the different pressures. Thus, again it would appear that in the presence of only a mild to medium development of early blight and the usual degree of insect infestation, spray applications made at rates as low as 40 gallons per acre and at pressures no lower than 60 p.s.i. should give a satisfactory degree of disease and insect control on potatoes. What the result would be during an epidemic of late blight is not known.

1954

The experimental procedure in the spraying of potatoes in 1954 followed much the same pattern as during the past 10 years, but more particularly that of 1953, in that special attention was given to a study of pressure-volume combinations with the accompanying droplet-size variations (31). Insecticide-fungicide formulations were tested on potatoes at Marietta, Wooster, and Willard, using the same series of treatments at each location (42, 43). The weather pattern for Ohio, and more specifically that in the vicinity of Wooster, continued to be similar to that of the last 3 years with less than the average amount of rain accompanied by above normal temperatures during several days in June and July. Rainfall during the period from May 1 to September 30 was less than half that of the 65 to 70-year average. As a result of this combination of weather factors, the foliage diseases of vegetables, and that includes potatoes, caused very little crop loss in 1954. Late blight was reported in only one or two isolated instances in the state and early blight was comparatively inactive on potatoes and tomatoes until early September when it became quite severe in west central Ohio on both crops.

In the three-location experiment (Marietta, Wooster, and Willard in 1954), 21 formulations and an untreated check were included in the series of treatments. Five different insecticides, as well as a mixture of DDT plus dieldrin, were formulated with Dithane Z-78 as a fungicide, and 12 different fungicides or fungicide formulations were used with the DDT-dieldrin (2-1) mixture. Four of the fungicides were applied in a 2X formulation at 80 gallons per acre at each experimental site. The DDT plus dieldrin combination was used in virtually all potato spray formulations in 1954 to afford better protection against flea beetles and thus avoid some of the damage caused by that insect in many of the experimental areas in 1953. The data obtained on foliage condition and yield in this three-way series are given in Table 66.

Early blight infection occurred earlier than usual in the Marietta planting and became quite severe on the untreated check plots and some of those treated with formulations least capable of controlling it. Leafhopper and flea beetle damage was no greater than usual and as a result there was very little difference in the foliage condition of the plots treated with the various insecticides. Strobane scored slightly below the others, not only at Marietta but also at the other two locations. It was definitely lowest in yield comparisons.

Dithane M-22 (maneb) gave the best yield at Marietta and was comparable to Dithane Z-78 and SDD plus Dithane D-14 plus $ZnSO_4$ (ziram plus zineb in treatment 12) in the control of early blight. Replacing half of the zinc in a tank-mix formulation of ziram (treatment 10) with copper (treatment 11) did not improve disease control or increase the yield. Replacing half of the dimethyl compound with Dithane D-14 (treatment 12), to give a mixture of ziram and zineb, gave some improvement over ziram alone. Adding manganese to the copper of Tribasic (treatments 14 and 13, respectively) had no effect in improving the performance of Tribasic. An organic manganese compound (Tennam 10) was not equal to Dithane M-22 in either disease control or production of tubers. Neither were two organic copper compounds (treatments 16 and 17) appreciably better than Tribasic, and one of them (WL-136) was slightly injurious. In average performance the four treatments applied in a 2X formulation at 80 gallons per acre (treatments 18, 19, 20, and 21) gave results in disease control and yield that were considerably poorer than those of the corresponding "X" formulations (treatments 2, 9, 13, and 8).

At Wooster where early blight had caused only about 50 percent defoliation, even by the end of the growth period (near normal harvest time), there was comparatively little difference in foliage scores or yields of the differently treated plots. All foliage scores on the sprayed plots were better than the unsprayed checks, but there were no significant differences in yield in the whole series of treatments.

Early blight infection was so severe in the Willard planting that the spray interval had to be shortened soon after mid-season to save the foliage from complete destruction in some of the plots. The check plots were estimated to have lost 90 percent of their foliage about August 15 (the data on defoliation given in the table are the averages of three readings, one of which was taken shortly after the first of August). The best foliage condition was estimated to be on the combination ziram-zineb plots (treatment 12) but this score was closely followed by the maneb (Dithane M-22) treatment. Dithane Z-78, in combination with most of the insecticide variations, gave very good early blight control, as zineb usually does, but a tank-mix formulation of zineb (treatment 10) was equally as good. The best yields were from the plots treated with zineb and maneb, and two organic copper compounds were lowest in yield and least effective in blight control (see percent foliage dead).

The most reliable index of comparative performance is usually the data on averages for the three locations. Here the best foliage score was furnished by the standard treatment (No. 2) of Dithane Z-78 plus a 2-1 mixture of DDT and dieldrin. This was closely followed by several others, including treatment 10 (ziram) and treatment 12 (ziram and zineb). Maneb (treatment 9) gave very good blight control also, especially at Marietta and Willard. The copper compounds, both inorganic and organic, gave the poorest control of early blight on the basis of these average values. The top yield resulted from the use of maneb (Dithane M-22), and this was followed in succession by Dithane Z-78, Tennam 10, Lo-738 (a carbamate), ziram plus zineb and zinc plus copper carbamate (treatment 11). The poorest yield resulted from the use of an organic copper compound (WL-136) which was slightly phytotoxic. An average of the four 2X formulations shows that they gave a yield which was 20 bushels per acre less than that for the corresponding "X" formulations and a defoliation percentage of 47 percent compared with 39 percent for the more dilute formulations applied at twice the gallonage. Thus, in this series of experiments the use of 80 gallons per acre of 2X formulations applied at 200 p.s.i. was somewhat inferior to the regular "X" formulations applied at 160 gallons per acre and a p.s.i. of 300.

In a continuation of this study on pressure-volume-droplet size spray-pattern studies, two more experiments were conducted in 1954, one on early-planted Cobblers and another on later-planted Katahdins. The data relative to the Cobbler series are given in Table 67. Early blight was again comparatively mild in its attack and late blight was absent. Dithane M-22 was used as the fungicide and the DDT-dieldrin mixture as the insecticide. There were no significant differences in yield between any of the treatments used in this series, and that, of course, included the untreated check plots, which showed a defoliation percentage of only 67 near the end of the growth period. There was some variation in the degree of defoliation of the differently sprayed plots, but these did not necessarily correspond with the yield values. There was comparatively little difference in the percentage of defoliation of the differently treated plots in the pressure series where the gallonage was held constant at 40 gallons per acre and the pressure varied from 200 down to 20 p.s.i. This was also true of the gallonage series where the pressure was held constant at 60 p.s.i. and the gallonage was varied between 10 and 80 gallons per acre. The 30-gallon rate appeared to be best, but there was no obvious reason for this, and the foliage condition on the 10-gallon plots was no worse than that on those treated at 80 gallons per acre. In the droplet-size series (treatments 11 to 15, inclusive) there was little difference in disease control and almost none in yield. The gallonage series applied in a hollow-cone pattern showed no variation in disease control as the application rate was varied from 20 to 160 gallons per acre. The low disease incidence was undoubtedly a factor contributing to a lack of definition in these results, but on the other hand, the similarity in performance of the different treatments was at least interesting from the standpoint of what can happen in such an experiment.

In a somewhat similar series of pressure-volume variations in spraying Katahdin potatoes later in the season, the data of Table 68 were obtained. Early blight became comparatively severe in this planting toward the end of the growth period and resulted in the complete defoliation of the untreated check plots about 2 weeks before harvest. Chiefly because of this, the yields of all treated plots were significantly better than those of the untreated plots. On the other hand, no significant differences in yield appeared in the treated plots. Neither was there any wide variation in the degree of defoliation on the differently sprayed plants. Dithane Z-78 was the fungicide and a 2-1 mixture of DDT and dieldrin the insecticide used in this experiment.

When pressure and gallonage were varied together (treatments 1 to 4, inclusive), there was no difference in either defoliation due to early blight or in yields from the differently sprayed plots. Where the gallonage was held constant at 40 gallons per acre and the pressures varied from 80 down to 20 p.s.i., the lowest pressure (20 p.s.i.) did as well as the highest (80 p.s.i.). A pressure of 60 p.s.i. gave good disease control and a comparatively high yield. When the pressure was kept the same (60 p.s.i.) and the gallonage varied from 80, 60, 40 and down to 30 gallons per acre (treatments 6, 9, 10, and 12), the 40 gallon-60 p.s.i. combination again gave the highest yield and good disease control. Thirty gallons per acre at 60 p.s.i. seemed slightly inferior to 80 gallons per acre in disease control. Again the data are not very definitive with regard to the effect on disease control of variations in rate and pressure of application. However, they do indicate that concentration (formulation), together with pressure-volume variations may not play as important a part as one might expect in determining the degree of disease and insect control that can be, and often is, obtained in spraying potatoes with effective control formulations.

A series of new fungicidal formulations were compared on Cobbler potatoes at Wooster in 1954. These included several organic copper compounds that were applied in comparison with Tribasic. Also, a number of metal-carbamate fungicides were compared one with another, and finally a number of different sulfates were added to sodium dimethyl dithiocarbamate (SDD) in a test of comparative performance with SDD plus $ZnSO_4$ (treatment 13). The data relative to this series are given in Table 69. The season was not conducive to the development of either early or late blight. Early blight did appear but caused too little defoliation to afford a definitive comparison of the ability of the fungicide formulations used in this series of treatments to control the disease.

Most of the treatments gave a barely significant increase in yield over the untreated check plots. All formulations gave some control of the mild attack of early blight, and treatment 7 (FF-31) caused sufficient foliage injury so that it appeared to be little better than the check. The highest percentage of live foliage at the end of the season was found on plots treated with Tennam 10. This was closely followed by plots sprayed with Lo-738, Dithane M-22, and SDD plus $ZnSO_4$. The latter, together with He-177 (treatments 13 and 11, respectively), gave the highest yields of the experiment. Dithane M-22 was in third place. Thus, few, if any, of the new formulations were essentially more effective than ziram (treatment 13) or maneb (treatment 12). The reason for the comparatively poor results obtained with zineb (treatment 9) in this experiment was not apparent. SDD plus $MnSO_4$, or manganese dimethyl dithiocarbamate, was definitely inferior to SDD plus $ZnSO_4$, as it has been in several other instances.

Several of the formulations used in the previous experiment were applied to later-planted Katahdins where early blight became much more destructive to potato foliage before the end of the growth period than it did on the earlier-maturing Cobblers. The data obtained with this series of treatments are listed in Table 70. There was a considerable variation in the degree of disease control by the different formulations included in this experiment. He-177 (copper ethylene bis dithiocarbamate) which checked early blight most effectively has also given good control of this disease on tomatoes in several different experiments. Several other dithiocarbamate formulations (treatments 6, 8, 9, 10, and 11) also gave good disease control.

There was little to choose between the new materials included in the first five treatments listed in Table 70, and treatment 12 was no better. This, together with treatments 2 and 3, failed to give a significant increase in yield over the untreated checks. Lo-738 (ethylene bis thiuram sulfide) was identified with the highest yield and was closely followed by Dithane Z-78 (zineb). SDD plus $ZnSO_4$ (ziram) was third in yield and in a virtual tie with He-177 and B-64 (an organic copper compound). In a consideration of both experiments (Tables 69 and 70), He-177 was the most promising of the experimental formulations.

The experiment relative to the effect of the spray schedule and the fungicides used in it on the chipping quality of potatoes was continued at Wooster in 1954 (44). Both Russet and Katahdin potatoes were sprayed with Bordeaux mixture and with Dithane Z-78 in the combination listed in Table 71. In addition, certain organic fungicide formulations and Tribasic were included in a second portion of the experiment located in the same field. The treatments listed in the first part of Table 71 were applied to 12 replicated plots and were harvested on three different dates, but treatments 8 to 13 were only applied to 4 replicates and were harvested only on the last date for treatments 1 to 7. The data of Table 71 consist only of the last harvest (October 14). Results obtained in the first two harvests will be published in a future publication on the influence of spray practices on chipping quality.

As was mentioned earlier in an introductory paragraph relative to the weather in 1954, the summer was very dry and warm, and thus was not favorable to the development of these two late varieties of potatoes. The vines actually wilted at times, and with no blight and very few insects to control the untreated check plots yielded as well or better than those that were sprayed with the insecticide-fungicide formulations. Even Dithane Z-78 plus DDT, which has not failed in about 40 experiments in which it has been used during the past 10 years to give a yield increase of 30 to 100 or more bushels per acre over the untreated check, did not give an increase in yield over the check. Bordeaux mixture, which is phytotoxic to some kinds of vegetable crops, and even causes a decrease in yield if foliage diseases are scarce (2), injured the potato vines sufficiently in this experiment to bring about a yield decrease of approximately 100 bushels per acre on both varieties. This was due chiefly to its unfavorable physiological effect on the potato foliage during periods when the plants were suffering from a lack of water in the soil (44). This sort of response has been observed several times in Ohio on tomatoes (2) but this was the first instance in which the more resistant potato has been so definitely injured and reduced in yield by Bordeaux mixture. Three of the formulations used in the second portion of the experiment (second section of Table 71) also caused a slight reduction in yield below that of its untreated check. There was virtually no difference in specific gravity of the tubers from the differently sprayed plots. All were very high and the tubers from each were very similar in chipping quality. Also, it should be noted that Russet and Katahdin potatoes harvested on September 15 and October 1 when the foliage in all plots was quite green and the skins slipped badly on the tubers, were actually of higher, and not lower, specific gravity than those harvested on October 14.

Data obtained in a series of insecticide experiments conducted at Wooster in 1954 are summarized in Table 72. Dieldrin was superior to all other materials tested in the control of the potato flea beetle. However, this insecticide gives relatively poor control of the potato leafhopper and in commercial practice best results are obtained by combining DDT and dieldrin in the spray tank. Parathion, malathion, Systox, Compound OS 2046, Pestox, and Compound 12008 gave good control of the potato and green peach aphids.

1955

The 1955 growing season was the most favorable for disease development of any during the last 5 years. Early blight became rather common in July and caused considerable defoliation on both potatoes and tomatoes during August and September at Wooster. Late blight also appeared on potatoes in the vicinity of Wooster in July and caused a considerable foliage loss in one of the experimental spray areas on the Station Farm in early September. Early blight caused a medium degree of defoliation in experimental plots at Marietta and Willard.

The three-location experiment on potatoes was repeated in 1955 and involved a comparison of six insecticides, all used with Dithane M-22 (maneb) as a fungicide, and seven fungicides were used with the 2-1 mixture of DDT and dieldrin. A half-strength Bordeaux mixture (4-2-100) was applied with and without a wetting and adhesive agent in an effort to determine what benefits in the way of better coverage and adhesion, and, of course, in disease control, might accrue from the use of these materials. This comparatively weak formulation was used to accentuate any improvement that might result over its possibly poor performance from better coverage of the foliage or better adhesion of the spray material. The data relative to the experiment are given in Table 73.

The data given in the last two columns of the table indicate that the addition of either the adhesive (K-704) or the wetting agent (Triton X-100) separately to Bordeaux mixture failed to improve the latter from the standpoint of disease control or yield. When the two materials were both added to the formulation, there was a slight improvement in average disease control and in yield. The greatest increases occurred at Marietta where the untreated check plots were most completely defoliated near harvest time.

Replacing half of the Bordeaux with 3 pounds of Tribasic, or what amounted to the same thing in replacing one-fourth of the Tribasic by a 2-1-100 Bordeaux, had little effect on the performance of either used alone (treatments 1 and 6), even though it had seemed possible that the Bordeaux fraction might improve the adhesion of the Tribasic used alone. The use of K-704 with Tribasic increased the effectiveness of the Tribasic slightly, but hardly enough to justify its use, although laboratory (greenhouse) experiments had indicated that the adhesiveness of Tribasic to tomato foliage was nearly doubled. Cop-O-Zinc (in which 4 percent of the copper content of Tribasic is replaced by zinc) gave better control of defoliation and a considerably higher yield than Tribasic in the averages of all three experiments.

Treatments 9, 11, and 14 involved a comparison of three different dithiocarbamates. Zineb, prepared by adding $ZnSO_4$ to nabam (Dithane D-14) gave the best results of the three compounds, both in terms of foliage condition and yield; in fact, both its foliage condition and yield were the best of the experiment. There was little to choose between the two manganese compounds (Tennam and Dithane M-22) in this experiment, since Tennam gave slightly better average foliage and Dithane M-22 (maneb) a slightly higher yield. Captan ranked somewhat lower in both foliage condition and yield than maneb, and considerably below zineb in both categories.

Treatments 11, 12, and 13 represent a comparison between the zinc, manganese, and copper, bis dithiocarbamates. The zinc compound (zineb) gave the best average results of the three, followed by copper carbamate, with maneb ranking third. Results on the control of early blight, and the defoliation caused by it, have been very good with the copper compound on staked tomatoes at Marietta during the past 2 or 3 years.

Treatments 14 to 19, inclusive, involve formulations of maneb (Dithane M-22) with several different insecticides. The average foliage condition near the end of the season was very similar for each of the six formulations, with the Systox-treated plants showing the least defoliation and the DDT-dieldrin combination (treatment 14) being only slightly poorer—but poorest of the group. In terms of average yield Systox was again the best, followed closely by the parathion-dieldrin formulation. The lowest yield occurred with the use of methoxychlor, and the yield with endrin was only slightly higher. Thus, the average data of these three differently located trials indicate that Systox should give very good control of leafhoppers on potatoes, especially when applied at 10-day intervals throughout the growth period of the potato.

The study, during the past few years, on the use of "concentrate" sprays and their application in the control of row crop diseases, was continued in 1955 by treating potatoes and tomatoes at Wooster with a hydraulic sprayer in an experiment designed to investigate the influence of droplet size of the spray particles on disease control. Air blast and airplane applications (45) were used on potatoes at Sandusky, but since diseases were absent the only useful data obtained there concerned insect control and swath distribution patterns of the spray material. Those will be presented later in another publication on the concentrate spraying of row crops.

The data relative to droplet size studies on potatoes are given in Table 74. In this experiment the fungicide-insecticide formulations consisted of Dithane M-22 and the usual DDT-dieldrin mixture. The spray applications were made on a 10-day schedule. Disease (early blight) was of only medium severity and insects were easily controlled. As a result, the untreated check plots yielded very well and only 5 of the 12 treatments gave a significantly higher yield. Neither was there any marked difference in foliage condition on the differently treated plots about 3 weeks before harvest.

The first three treatments of Table 74 were applied with different sized nozzle apertures, 9502 being the smallest and 9508 the largest. All were applied in a 4.6X formulation at 40 p.s.i. and 35 gallons per acre. There was little difference in foliage condition, nor was any one yield significantly different from the other two. There was some indication that the largest droplets, formed by the 9508 nozzle tip, gave somewhat less disease control than did the smaller droplets from the other two nozzles. Although the droplets formed by the nozzle discs D4 and DIO (hollow-cone patterns) were quite different one from another in size, the results obtained in disease control were almost identical.

When all other conditions tending to regulate droplet size except pressure were the same (treatments 6, 7, and 8), it appeared that the smaller droplets formed at 250 p.s.i. gave somewhat better results than did the larger droplets issuing at 30 p.s.i. When the pressure was held constant and droplet size was varied by using disc apertures of different diameters, and the application rate per acre was varied by differences in the forward speed of the tractor (treatments 9, 10, 2, 11, and 12), there was some difference in foliage condition, but still there was comparatively little difference in yield. The very small droplets of the highly concentrated formulation (16X) applied with the "95015" disc aperture gave somewhat poorer disease control than that afforded by 60 and 80 gallons of weaker formulations applied with the 9502 and 9504 discs used to apply 60 and 35 gallons per acre, respectively.

Thus, in summary, it would seem that when variations in pressure and volume are used to obtain differences in droplet size, as well as differences in the quantity of water used to apply spray formulations of different concentration, the differences in disease and insect control are not as great as one might expect they would be. However, this conclusion must be modified by calling attention to the fact that late blight was absent and early blight was only moderately active in the experimental area.

In a further test on the influence of various adjuvants on the performance of copper fungicides, various Triton variations, an adhesive (K-704), and a mixture of cottonseed oil and Triton 1956 (Veg-Oil) were formulated with Tribasic and applied to potatoes at Wooster. The data relative to this experiment are given in Table 75.

Both early and late blight appeared in this planting, and one or the other caused rather severe defoliation by early October. The use of the polyacrylate polymer (K-704) as an adhesive for Tribasic improved the action of the fungicide to some extent, as shown by a decrease in defoliation and an increase in yield. The addition of Triton X-100 to Tribasic improved disease control to some degree, but the yield increase was negligible. This was also true of X-411. Triton X-104 seemed to have little effect, but Veg-Oil did improve the performance of Tribasic in this experiment by definitely improving blight control, and this was accompanied by an increase in yield. The mixture of K-704 and Triton X-100 (treatment 4) failed to show the beneficial effect here that it exhibited with Bordeaux in some of the experiments where both were used.

The use of parathion as an insecticide with Tribasic gave the best foliage condition of the experiment with a definite improvement in disease control and a marked increase in yield. SDD plus $ZnSO_4$ (ziram) failed to give satisfactory control of late blight in this instance, and as a result defoliation was much more severe and the yield was lower than with zineb.

An experiment designed to study the control of potato diseases and insects with air blast and airplane applicators was conducted on the Osborne Welfare Farm in 1955 (45). This was done in cooperation with the Department of Agricultural Engineering at The Ohio State University. The season was very dry and foliage diseases were virtually absent, even in the untreated check. Insects were more numerous in this check area, especially flea beetles. Because of this lack of disease, and the almost perfect control that was obtained of insects, there was no significant difference in the yield of potatoes from the differently treated plots. The data relative to the experiment are given in Table 76.

Copper deposit data indicated that applications made at 5 gallons per acre of a 30X formulation deposited less copper on the leaves than when 10 gallons of a 15X, or 15 gallons of a 10X, were applied. The 15 gallon-10X application was most effective in this respect. The respective values in micrograms per square centimeter of leaf surface for the 5, 10, and 15-gallon applications were 19.5, 23.0, and 28.4. The copper deposit data for the air-blast applications were not quite so definitive but were as follows:

Gallons applied per acre	20	30	40
Concentration of formulation	7.5X	5.0X	3.75X
Micrograms cu/sq. cm.	33.2	24.8	27.1

This represents an average deposit value of 28.4 micrograms of copper for air-blast application and 23.6 micrograms for the airplane. Coverage was good in both instances.

DISCUSSION

As was mentioned early in this bulletin, the period of time from 1943 to 1955 represents an interval during which both fungicides and insecticides for use on potatoes underwent a change in chemical composition much greater than that which had taken place from the time that Bordeaux mixture was discovered in the early 1880's, and from the first use of Paris green about 1865, until the 1940's. The dithiocarbamates entered the experimental picture in the late 30's with the introduction of ferbam (Fermate), and DDT appeared in the early 40's. Ziram and zineb came along soon after ferbam, but other new insecticides such as dieldrin and parathion followed DDT after a longer interval.

The formulation of zineb plus DDT became the first choice of Ohio growers only a few years ago, and still more recently DDT has been supplemented by the addition of dieldrin to give better control of flea beetles. Parathion is used by still other farmers. Zineb has been progressively proving its superiority as a potato fungicide each year for the past decade, until now it is used on at least three-fourths, and perhaps four-fifths of the commercial potato acreage in Ohio.

The large number of experiments and the fact that many of them have not dealt directly with the search for control measures would seem to make it advisable to summarize the data relative to the performance of specific materials as they have been compared, one with another during various years. This has been done for those compounds (fungicides and insecticides) which have, and in many instances still do, appear with considerable frequency on the dealers' shelves and in the control recommendations issued by vegetable pathologists and entomologists. Zineb is unquestionably the fugicide most used on potatoes today, at least in Ohio, and it will be discussed first.

During the period from 1943, when it was first tested under the code number of He-175 until the present, when the common name of "zineb" is used to designate the product which now is known under several different trade names, it has been used in 53 experiments in the experimental spray program in Ohio. In many of these trials it was compared with various other fungicides such as Bordeaux mixture, a number of the fixed coppers, and several formulations of ziram, as well as maneb. In addition, the wettable powder, as prepared by the manufacturer, has been compared in at least 25 experiments with the tank-mix formulation as it is prepared in the field by adding solubilized zinc sulfate to sodium ethylene bis dithiocarbamate, or nabam. Comparative yield and disease-control data for these various types of comparisons are given in Table 77.

The yield-increase values as given in the following tables are, of course, not entirely due to the use of a fungicide, but rather to the combined effect of whatever fungicide-insecticide formulation that was used in specific instances to control both diseases and insects. The effect of DDT alone in increasing the yield of potatoes over that obtained from an untreated check area was frequently as much as 100 bushels per acre in early tests (See Table 80). What it now may be in any particular instance is largely dependent on the leafhopper population to be controlled, since flea beetles and aphids usually are less effective than leafhoppers in reducing potato yields in Ohio. Another factor that must be considered in measuring the effect of DDT on yield, and that of various other insecticides as well, is the tendency of the control material to reduce the normal degree of insect injury in small isolated check plots by virtue of the fact that the populations as a whole are reduced and migration from areas outside the experimental site is held to a minimum far below what it would be if the insects did not encounter treated barriers before reaching the untreated plants. This situation may also exist, but to a much lesser extent, with respect to the incidence of disease on untreated check plots, since the inoculum source may be reduced through a decrease in the number of fungus spores that would otherwise be produced if disease development were not checked by the presence of the fungicides being applied. Thus, since DDT was used as the insecticide with virtually all of the fungicides listed in the summary tables, the values given as representing average yield increases due to the use of a given fungicide must be reduced by some arbitrary figure, the exact value of which is not known, but which in most instances may represent approximately half of the increase indicated. This discrepancy in values is usually much less than 50 percent where foliage condition is concerned, since defoliation is more likely to be due to disease than to insect attack, although here again it is difficult to assign a definite value to either factor. Thus, where an attempt is made to evaluate the effect of a single fungicide on yield, or the degree of defoliation, it must be remembered that part of the effect is due to the insecticide with which it is formulated. However, where a comparison is made between two fungicides, both used with the same insecticide, the difference in values is due almost entirely to a differencee in the ability of the two fungicides to control disease, and thus to affect the resulting yield.

In Table 77, zineb, together with the insecticide with which it was formulated (which was DDT in most instances), gave an average yield increase of 108 bushels per acre in 52 experiments and an average decrease in defoliation (degree of disease control) below that of the untreated checks of 53.7 percent. This was the best long-time record compiled by any fungicide used in the experiments reported in this bulletin, although its performance was closely followed by that of ziram in many experiments where late blight was not present. This performance record over a period of the 12 years since its first use as an experimental fungicide in Ohio has undoubtedly been a contributing factor in bringing about the increasing use of zineb as a potato fungicide in Ohio.

In approximately half of the 53 experiments in which zineb has been included (25 in all), it has been applied in both the wettable powder and the tank-mix formulations. The average performance of the two formulations has been almost identical, as is indicated in the second item listed in Table 77. The average yields have been exactly the same, but the wettable powder formulation has given just slightly the better foliage condition (disease control).

The relative merits of zineb and Bordeaux as a potato fungicide have been discussed at length by various plant pathologists. The concensus of opinion is that Bordeaux may be depended upon to give the better control of late blight whenever the spray interval is as long as 7 to 10 days and that zineb will give the better control of early blight. It is less phytotoxic than Bordeaux and potatoes sprayed with zineb usually produce a larger yield than those treated with Bordeaux, especially in the northern section of the United States. This has been true in the majority of the tests in which the two materials have been compared in Ohio, especially when late blight was absent or of no more than medium severity. This statement is borne out by the averages for disease control and yield in 26 comparisons (item 3 in Table 77) in this series of experiments. In these 26 experiments the zineb-treated plots outyielded those sprayed with Bordeaux by 35 bushels per acre, and showed 5 percent less dead foliage at the time the check plots had lost an average of 78 percent of their effective foliage area.

Comparisons between zineb and various fixed coppers have been made in numerous experiments. Tribasic and zineb were both included in at least 43 different tests and the comparative averages for each are given in item 4 of Table 77. Zineb increased the yield over the untreated check plots by 123 bushels per acre or by 34.2 percent, whereas Tribasic gave a yield increase of only 87 bushels over the check, or about 24 percent. Zineb gave 55 percent control of defoliation and Tribasic fell 15 percent below that. When COC-S was compared with zineb in 32 experiments (item 5 in Table 77), the average check yield was 359 bushels per acre. This was increased 124 bushels per acre by the insecticide-fungicide formulation that included zineb, or a percentage increase of 34. When COC-S was used, an increase of 95 bushels was equivalent to a percentage gain of only 26. The average percentage of defoliation in all 32 experiments was 37.3 percent with zineb and 45.6 percent with COC-S as the fungicide. This was about 51 and 40 percent control of an untreated average defoliation of 76 percent, respectively.

TABLE 77.—The average effect of zineb plus an insecticide of whatever formulation, on disease control and yield of potatoes in Ohio over a period of 12 years. Also, how its effectiveness compared with various other fungicides during all or part of those years

Fungicide	Number of comparisons	Yield				Percent Defoliation		
		Bu./Acre						
		Checks	Treatments	Increase	Percent increase	Checks	Treatments	Percent control
1. Zineb only	53	345	453	108	31.3	74.9	34.7	53.7
2. As a wettable powder	25	372	489	117	31.4	76.2	30.7	59.7
As a tank-mix formulation			489	117	31.4		31.1	59.2
3. Zineb vs.	26	334	472	138	41.3	77.9	36.2	53.5
Bordeaux			437	103	30.8		41.3	47.0
4. Zineb vs.	43	360	483	123	34.2	73.8	33.3	54.9
Tribasic			447	87	24.2		44.9	39.2
5. Zineb vs.	32	359	483	124	34.4	75.8	38.3	50.8
COC-S			454	95	26.4		45.6	40.0
6. Zineb vs.	41	335	452	117	35.0	75.3	34.7	53.9
Ziram			433	98	29.3		40.0	46.8
7. Zineb vs.	26	315	434	109	34.6	69.5	32.4	53.4
Maneb			420	105	33.3		33.8	51.3
8. Zineb vs.	5	485	576	89	18.4	75.4	29.8	60.5
Captan			526	41	8.5		46.6	38.2

Ziram, whether used in wettable powder, slurry, or tank-mix formulations, fell short of zineb as a potato fungicide in this series of experiments. The two zinc compounds were both used in 41 different tests, and the average data for these are given in item 6 of Table 77. As will be indicated later, both the slurry (Methasan S) and tank-mix formulations were usually more effective in disease control than was the wettable powder (Zerlate), but since all consisted of the same chemical compound (zinc dimethyl dithiocarbamate) they were included in the averages in whatever experiments one or another of them was used. The average yield for zineb and ziram differed by 19 bushels per acre, with ziram giving the lower yield. The difference in favor of zineb was proportionately about the same in terms of disease control. An average defoliation in the untreated check plots of 75.3 percent was reduced to 34.7 percent by zineb and to 40.0 percent by ziram. These values were equivalent to a percentage control of 54 and 47 percent, respectively, for the two compounds. This difference in favor of zineb was rather consistent throughout most of the experiments, but was most marked in favor of the "ethylene bis" material in those tests in which late blight was present.

One of the newest among potato fungicides, and particularly among the dithiocarbamates, is maneb. It has been used in 26 experiments since 1949 in which zineb was also included. The average data on yield and defoliation for these two materials are given in item 7 of Table 77. These values indicate that maneb may be expected to give nearly as good results on potatoes as zineb, but since it costs somewhat more it has not been as generally used, even during the last 2 or 3 years when it has been easily obtainable on the market. It has fallen only 4 bushels per acre short of zineb, and the average defoliation on the maneb plots has been only 1.4 percent less than that on those treated with zineb.

In 1954, a fourth dithiocarbamate (copper ethylene bis dithiocarbamate, or He-177) was compared with ziram, zineb, and maneb in six different experiments. The average untreated check yield was 300 bushels per acre. The increase, when an insecticide was formulated with each of these, was 64, 63, 70, and 66 bushels per acre for ziram, zineb, maneb, and He-177, respectively. The corresponding percentages of defoliation were 33.0, 35.7, 32.3, and 38.3, whereas the check showed a foliage loss of 67.3 percent. These data indicate that the four compounds were closely similar in their ability to control early blight in 1954.

In item 8 of Table 77, the average data are given for five comparisons between zineb and another new fungicide known under the common name of captan. In these few experiments, captan failed to control early blight as well as zineb, and it did not give a comparable increase in yield.

Fermate (ferbam) was the first of the dithiocarbamates to be tested on potatoes in Ohio. It gave good disease control and an excellent yield in its first trial (6), but this performance was not duplicated again, and ziram soon replaced it as a new material for the control of various vegetable diseases, including those of potato.

The average performance of ziram in 42 experiments carried out over a period of 12 years is given in Table 78. It will be remembered from the previous table (No. 77) that ziram failed to equal zineb in disease control or yield, but it has done very well in many experiments, aiding its insecticidal partner in giving a yield increase of 90 bushels per acre and a 47.4 percent decrease in defoliation.

It has been indicated previously by the senior author (39) that a tank-mix formulation of ziram (sodium dimethyl dithiocarbamate plus zinc sulfate) usually gives better results than the wettable powder preparation, and this is demonstrated in the data of item 2 in Table 78. In 13 trials the tank-mix ziram outyielded the wettable powder by 9 bushels per acre (3 percent) and gave considerably better control of defoliation. In fact, this tank-mix preparation has given results comparable to maneb and zineb in several experiments where late blight was not a factor in defoliation.

A slurry formulation of ziram, in which the original precipitate was used as a thick paste in preparing the mixture for field spraying, gave an equally good account of itself in 12 comparisons with the wettable powder (item 3, Table 78). Vancide 51, which is a modified formulation of ziram, also exceeded the wettable powder form of ziram in performance (item 4, Table 78), whereas Zac, another modification (see Materials Key) equalled Zerlate in disease control, and did nearly as well in increasing the yield of potatoes (item 5, Table 78).

Ziram in the form of Zerlate was compared with several of the fixed coppers over a period of 10 years or more, from 1943 onward. Comparative data showing the average performance of ziram and Tribasic and ziram and COC-S in over 30 experiments, when all were used with the same insecticide, are given in items 6 and 7, respectively, of Table 78. Ziram produced a considerably better yield than either of the copper compounds, and gave slightly better disease control.

TABLE 78.—The comparative effectiven ss of various formulations of ziram in the control of potato defoliation due to early and late blights and the corresponding increases in yield. The average performance of maneb is also indicated, as well as the effect of adding p.e.p.s. to various fixed coppers and dithiocarbamates

Fungicide	Number of comparisons	Yield				Percent Defoliation		
		Bu./Acre						
		Checks	Treatments	Increase	Percent increase	Checks	Treatments	Percent control
1. Ziram only	42	334	424	90	27.0	76.0	40.0	47.4
2. As a wettable powder	13	306	383	77	25.2	67.4	38.3	43.3
As a tank-mix formulation			392	86	28.2		30.8	54.3
3. Ziram	12	383	480	97	25.3	83.0	42.9	49.4
Methasan slurry			488	105	27.4		36.3	56.3
4. Ziram	9	351	433	82	23.4	71.1	36.6	49.0
Vancide 51			437	86	24.5		31.1	56.4
5. Ziram	19	383	468	85	22.2	79.3	40.7	48.7
Zac			460	77	20.1		40.7	48.7
6. Ziram	34	353	466	113	32.0	74.9	40.0	46.6
Tribasic			441	88	25.0		44.0	41.2
7. Ziram	32	348	463	115	33.0	80.0	44.4	44.5
COC-S			447	99	28.4		46.5	41.9
8. Maneb	27	345	427	82	23.8	68.2	36.5	45.0
9. As a wettable powder	14	316	402	86	27.2	67.0	32.0	52.2
As a tank-mix formulation			396	80	25.3		37.3	44.3
10. Fixed coppers	33	346	409	63	18.2	74.0	46.8	36.8
Fixed coppers + p.e.p.s.			421	75	21.7		41.0	44.6
11. Dithiocarbamates	33	337	413	76	22.5	74.0	33.5	54.7
Dithiocarbamates + p.e.p.s			421	84	24.9		31.7	57.2

Maneb was the last of the dithiocarbamates to come into general use as a vegetable fungicide. To date it has been included in 27 experiments on potatoes, and the average yield and disease-control data are given in item 8 of Table 78. Here it should again be recalled that it fell slightly below zineb in both categories in 26 experiments in which both compounds were used. However, it has given very good results in most of the experiments where it has been applied as a potato fungicide. Contrary to the experience with zineb and ziram, the tank-mix formulation of maneb has not been the equal of the wettable powder in the control of potato and tomato diseases (39), and this is demonstrated clearly in the data of item 9 (Table 78) where the averages for 14 comparisons between the two formulations are given.

Polyethylene polysulfide (p.e.p.s.) was used as an adhesive with various fixed coppers and dithiocarbamate fungicides in 33 experiments on potato spraying over a period of several years. The average results obtained with copper and organic compounds are given in items 10 and 11, respectively, in Table 78. The material gave a considerable increase in disease control and in yield when used with the chemically stable fixed coppers, but was less effective in improving the performance level of the more rapidly deteriorating dithiocarbamates. Since p.e.p.s is a mild fungicide in its own right, it should be a promising adhesive for use with potato fungicides.

Bordeaux mixture has been, and still is, one of the standard fungicides for use on potatoes. However, its almost universal usage was first challenged in the 1930's by the advent of the fixed coppers (6, 9, 10), which could be used on many vegetables including potatoes, without the addition of lime to the spray formulation. There were several of these (possibly 20 or more) introduced during the 15-year period from 1930 to 1945, most of which were either tribasic sulfates, oxychlorides, or oxides of copper, and several of these were included in one or more of the series of experiments reported in this bulletin (see Materials Key).

Since a trioxysulfate of copper commonly known as Tribasic has been most generally used in this experimental series, it has been chosen as the standard material with which a number of other copper-containing fungicides are compared in Table 79. The first eight items in the table represent the average results obtained when different copper compounds were used as individuals, and the last five (items 9 to 13, inclusive) list comparisons between Tribasic and other copper-containing materials.

Tribasic was used in at least 44 different experiments, usually in comparison with other fungicides, and the average data obtained when it was applied in combination with an insecticide are given in item 1 of

TABLE 79.—The average effectiveness of various fixed coppers, including Bordeaux mixture, plus an insecticide in controlling the defoliation and in increasing the yield of potatoes in Ohio over a period of 13 years

Fungicide	Number of comparisons	Yield Bu./Acre				Percent Defoliation		
		Checks	Treatments	Increase	Percent increase	Checks	Treatments	Percent control
1. Tribasic	44	355	429	74	20.8	73.4	44.4	39.5
2. Cop-O-Zinc	23	407	486	79	19.4	74.9	38.0	49.2
3. COC-S	42	342	434	92	26.9	76.6	44.1	42.4
4. Crag 658	26	400	493	93	23.3	79.1	39.0	50.7
5. Bordeaux	28	319	420	101	31.5	75.5	40.8	46.0
6. Robertson Fungicide	17	386	445	59	15.3	77.3	42.0	45.7
7. Copper cupferron	9	410	486	76	18.5	80.0	39.2	41.0
8. Bioquin 1	6	394	495	101	25.6	78.8	45.0	42.9
9. Tribasic	22	404	473	69	17.1	74.9	45.7	38.9
Cop-O-Zinc			483	79	19.5		37.9	49.4
10. Tribasic	29	370	463	93	25.1	79.1	45.5	42.5
COC-S			462	92	24.9		45.7	42.2
11. Tribasic	23	415	495	80	19.3	78.6	45.8	41.7
Crag 658			509	94	22.6		39.0	50.4
12. Tribasic	14	368	500	132	35.9	78.5	41.3	47.4
Bordeaux			497	129	35.1		41.1	47.6
13. Tribasic	14	383	437	54	14.1	77.5	45.0	42.0
Robertson Fungicide			445	62	16.2		43.5	43.7

Table 79. The average increase of 74 bushels per acre over the untreated checks was not outstanding among most of the fungicides listed here, but it has consistently given good results, especially when late blight has been a factor in causing an appreciable degree of defoliation of the potato plants. The average percentage of disease control has not been as high (39.5 percent) as that afforded by several others of the copper-containing and synthetic (organic) fungicides used, but neither has it failed to give a satisfactory degree of control in most instances.

Cop-O-Zinc (C-O-Z) has been compared with Tribasic in 23 experiments (item 2, Table 79). The presence of the small proportion of zinc in this predominantly copper-containing formulation has perhaps added something to the ability of the mixture to control disease and thereby increase yields, but it is possible that it (the zinc component) has acted as a nutritional element in some experiments to keep the potato vines in better condition. The average increase in yield over Tribasic of 5 bushels per acre is not striking, but a nearly 10 percent improvement in vine condition is worthy of note. Just how it did compare with Tribasic is better shown in item 9 (Table 79) where comparative data for 22 experiments are given. Here the increase in yield over Tribasic was 10 bushels per acre and the control of defoliation was 10.5 percent greater. This difference in favor of Cop-O-Zinc over Tribasic would seem to indicate the desirability of using the former on Ohio potatoes.

COC-S, an alphabetical name for a mixture of copper oxychloride and tribasic copper sulfate, was originally prepared with the thought that such a formulation would combine the greater fungicidal activity of the oxychloride with the less phytotoxic property of the tribasic sulfate (19). Actually the mixture proved to be a slightly better potato fungicide than Tribasic, as may be seen in comparing items 3 and 1 in Table 79, although the data of item 10 indicate that the two compounds gave almost identical results in 29 experiments in which both were applied with the same insecticide, or insecticides.

Crag 658 (item 4, Table 79) is another specially compounded copper-containing fungicide that was included in 26 different experiments, mostly in the period from 1946 to 1950 (28). It gave a yield increase comparable to that furnished by COC-S and a degree of disease control similar to that of Cop-O-Zinc. In fact, it was the only one of the copper-containing fungicides listed in Table 79 that gave more than 50 percent control of defoliation. In a total of 23 experiments in which it was compared with Tribasic it gave an average increase in yield over the latter of 14 bushels per acre (item 11) and a somewhat better control of disease. A slightly greater cost has perhaps been the principal deterrent to its being more widely used on potatoes.

Bordeaux mixture, still the most widely used of the copper fungicides, and about which hundreds of pages have been written extolling its virtues and deficiencies (2, 4, 6, 10, 14, 18, 22, 33, 44), is not by any means as generally used on potatoes as it was 15 to 20 years ago (4). However, in the beginning of the transition period from Bordeaux to fixed coppers and then to the dithiocarbamates as it is covered in this bulletin, Bordeaux mixture was used in 28, or more, experiments. The average data on yield and disease control in these trials are given in item 5 of Table 79. The average increase of 101 bushels per acre over the untreated checks, which this fungicide plus the insecticides formulated with it, was equalled only by Bioquin among the copper fungicides listed in Table 79, and the 46 percent control of defoliation which it gave was exceeded only by Cop-O-Zinc and Crag 658. In a comparison with Tribasic in 14 experiments (item 12, Table 79) it was in a virtual tie with that material in both disease control and yield. There have been several reasons for the decrease in its use as a potato fungicide during the last 20 years, in fact too many to list and discuss here, but not the least among which was its tendency to reduce yields, because of certain phytotoxic properties.

Various cuprous oxides have been introduced as potato fungicides during the past 20 years (6). Several of these have been used in the series of experiments discussed in this bulletin (see Materials Key), but only one of them is included in the data of Table 79. This is Robertson Fungicide (item 6), which is composed of many very small particles of metallic copper, each of which is coated with a thin layer of cuprous oxide making up about 20 percent of the total weight. The cuprous oxides are basically cheaper than most other forms of copper fungicides, but all of them are inherently somewhat phytotoxic, and this is possibly one of the reasons they have not been more generally used as potato fungicdes. In an average of 17 experiments in which Robertson Fungicide was applied to potatoes, it accounted (with the insecticide with which it was formulated) for a yield increase of only 59 bushels per acre, the lowest among the copper compounds listed in this summary. The percentage of disease control, as indicated by the data on defoliation, was comparatively good. However, in many instances the leaves on plants sprayed with this fungicide were smaller and thicker than normal and the vines assumed a comparatively prostrate habit of growth. In a comparison with Tribasic in 14 experiments (item 13, Table 79), the results, in terms of yield and disease control, obtained with Robertson Fungicide were at least as good if not slightly better than with Tribasic.

Two other copper fungicides are listed in Table 79. Copper cupferron was used in nine experiments (item 7, Table 79) where it gave results in terms of yield increase and disease control that were comparable with those obtained with Tribasic, the standard of comparison used in Table 79. Bioquin, which in the opinion of the senior author is one of the most promising of the copper fungicides tested in this series of experiments, was used in six trials in the late 1940's. The average increase in yield was excellent and its control of defoliation was at least of average degree. This was true in spite of the fact that in most of the experiments in which it was tested an effort was made to use it at the lowest possible rate where it would give control, because of its inherently high cost of manufacture. It was this cost feature which finally ruled it out of competition as a potato fungicide. As may be seen in a comparison of the number of fungicides and fungicidal formulations listed in Tables 77, 78, and 79, and those listed in the Materials Key, only a small percentage of the total has been listed in the above "discussion". Many of those omitted were left out because they were used in too few experiments to furnish a good comparison with others in average performance, whereas others were so strictly experimental in nature that they were not tested further following initial failure. If the reader wishes to evaluate any of those omitted from this section, it may be done by referring to those individual experiments in which any specific compound or formulation was used.

Table 80 summarizes the data relative to the effectiveness of copper, calcium arsenate, DDT, and combinations of these materials in the control of leafhoppers and flea beetles. Copper-containing materials used alone gave 89.3 percent control of leafhoppers and 46.9 percent control of flea beetles. Yields were increased 55.3 percent over untreated check plots. The addition of calcium arsenate to the copper spray mixture gave a slight increase in the control of flea beetles. DDT used alone gave complete control of the potato leafhopper and a 43.6 percent increase in yield over the untreated check plots. When DDT was combined with copper-containing materials, flea beetle control was improved and yields were increased 56.2 percent over the untreated check plots.

In Table 81 data are presented showing the effectiveness of various insecticides in controlling insects and in increasing yield. An important factor that should be considered in comparing insecticides is the tendency of materials that give relatively poor control of insects to appear better than they actually are when used in an experimental planting where most of the plots are treated with highly effective insecticides. This is due to the fact that adult leafhoppers and flea beetles

TABLE 80.—Comparative effectiveness of DDT, calcium arsenate, copper compounds, and combinations of these materials in controlling leafhoppers and flea beetles and in increasing yields

Treatments	Number of comparisons	Yield				Leafhoppers			Flea Beetle		
		Bushels per Acre				No. nymphs/100 leaves			No. holes per leaflet		
		Check	Treat-ment	Increase	Percent increase	Check	Treat-ment	Percent control	Chcek	Treat-ment	Percent control
1. DDT only	10	298	428	130	43.6	807	0	100	34	10	70.5
2. Copper only	11	197	306	109	55 3	1089	116	89 3	149	79	46 9
3 Copper + Ca. Ars.	32	259	303	44	16 9	786	84	89 3	91	33	63.7
4. Copper + DDT	20	290	453	163	56 2	625	0	100	63	8	87.3

TABLE 81.—Comparative effectiveness of various insecticides combined with a fungicide in controlling insects and in increasing yields

Insecticides	Number comparisons	Yield: Bushels per Acre				Leafhoppers: No. nymphs/100 leaves			Flea Beetle: Number holes per leaflet			Percent defoliation		
		Check	Treatment	Increase	Percent increase	Check	Treatment	Percent control	Check	Treatment	Percent control	Check	Treatment	Percent control
1 Methoxychlor	17	373	497	124	33.2	810	0	100	79	9	88.6	71	41	42.2
DDT			542	169	45.3		0	100		9	88.6		35	50.7
2 BHC	12	344	478	134	38.9	1101	310	71.8	121	9	92.5	60	41	31.6
DDT			544	200	58.1		0	100		7	94.2		32	46.6
3 TDE	8	330	529	199	60.3	1135	0	100	129	15	88.3	81	43	46.9
DDT			578	248	75.1		0	100		9	93.0		36	55.5
4 Malathion	20	373	468	95	25.4	810	0	100	92	24	73.9	77	53	31.1
DDT			470	97	26.0		0	100		18	80.4		55	28.5
5 Parathion	25	386	573	187	48.4	490	0	100	83	16	80.7	77	43	44.1
DDT			540	154	39.8		0	100		14	83.1		45	41.5
6 Toxaphene	7	402	527	125	31.1	1540	20	98.7	92	11	88.0	78	50	35.8
DDT			529	127	31.5		0	100		11	88.0		50	35.8
7 Aldrin	14	361	423	62	17.1	1060	305	71.2	79	6	92.4	71	37	47.8
DDT			482	121	33.5		0	100		13	83.5		39	45.0
8 Dieldrin	12	357	465	108	30.2	735	200	72.7	92	4	95.6	64	34	46.8
DDT			460	103	28.8		0	100		20	78.2		37	42.1
9 Endrin	8	393	506	113	28.7	550	70	87.2	43	19	55.8	70	41	41.4
DDT			490	97	24.6		0	100		23	46.5		42	40.0
10 Dilan	13	430	548	118	27.4	840	0	100	61	13	78.6	76	43	43.4
DDT			538	108	25.1		0	100		15	75.4		46	39.4
11 Strobane	7	309	410	101	32.6	380	30	92.1	30	18	40.0	59	35	40.6
DDT			430	121	39.1		0	100		19	36.6		33	44.0
12 Systox	17	398	484	86	21.6	496	3	99.3	36	24	33.3	69	39	43.4
DDT			486	88	22.1		0	100		20	44.4		40	42.0
13 EPN	9	436	568	132	30.2	495	20	95.9	20	17	15.0	82	48	41.4
DDT			581	145	33.2		0	100		13	35.0		49	40.2
14 Heptachlor	6	497	547	50	10.0	1300	740	43.0	41	13	68.2	75	55	26.6
DDT			551	54	10.8		0	100		6	85.3		64	14.6
15 Chlordane	8	406	583	177	43.5	1565	315	79.8	124	22	82.2	78	49	37.1
DDT			602	196	48.2		0	100		13	89.5		49	37.1

move freely within the experimental planting and they come in contact sooner or later with a lethal dose of an insecticide or combination of insecticides, thereby reducing the insect population within the entire experimental area. A material that does not give complete control of the potato leafhopper will give a significantly lower yield than DDT when the two insecticides are compared in a properly planned experiment. In these experiments a material which did not give complete control of the potato leafhopper was rated as inferior.

DDT, methoxychlor, TDE, malathion, parathion, Dilan, and Systox gave excellent control of the potato leafhopper and correspondingly larger yields. Benzene hexachloride, toxaphene, aldrin, dieldrin, chlordane, Strobane, EPN, endrin, and heptachlor were inferior to the above materials in the control of the potato leafhopper.

DDT when first introduced was fairly effective in controlling the potato flea beetle, but during the past few years this insect has developed a high degree of resistance to DDT. DDT-resistant flea beetles were controlled with parathion, toxaphene, heptachlor, aldrin, and dieldrin. In these experiments, dieldrin was superior to all other materials studied in the control of the potato flea beetle.

Data not included in Table 81 show that parathion gives excellent control of whiteflies and that both the green peach and the pink and green potato aphids are controlled with parathion, malathion, and Systox.

CONCLUSIONS

1. The introduction of DDT and its use as a potato insecticide was responsible for a greater increase in yield than any other single factor in the history of Ohio potato production.

2. The importance of leafhoppers in regulating Ohio potato yields was demonstrated by the fact that DDT in completely eliminating this insect from potato plots increased the yield 53 percent over that obtained with copper-containing materials which failed to kill the last 10 percent of the population.

3. DDT has become progressively less effective against flea beetles during the last 12 years, due to the development of resistance to it by the insect. As a result, it is now recommended that a mixture of DDT and dieldrin be used on Ohio potatoes to give better control of the flea beetles while still maintaining control of leafhoppers.

4. In 1944, when DDT was used on only a few plot replicates in an experimental planting, it influenced (decreased) leafhopper populations as much as 8 feet from the row being treated—but not much farther.

5. Bordeaux plus DDT gave better results than either used alone, indicating that both were necessary in their respective categories.

6. The insecticidal efficiency of DDT made the use of Bordeaux to improve insect control unnecessary and hastened the replacement of that fungicide by the dithiocarbamates, which are relatively inactive as insecticides.

7. Less than 3/8 pound of DDT per acre was found to be too little for best results in controlling potato insects, particularly leafhoppers, but quantities above this gave little additional control.

8. DDT applied alone in early tests usually gave a larger potato yield than any combination of the fungicides then available with calcium arsenate.

9. The use of extra lime in Bordeaux mixture had little influence on the effectiveness of DDT; however, the use of an excess of lime with DDT is said to be undesirable.

10. When DDT was first introduced (in the mid-40's) it checked flea beetle feeding for 6 days, whereas calcium arsenate was effective for only four.

11. Bordeaux mixture applied to potatoes during a dry summer reduced the yield below that of the untreated check by as much as 50 to 100 bushels per acre (10 to 20 percent), whereas zineb-treated plots equalled the check in yield.

12. Specific gravity values, and the chipping quality of potatoes treated with zineb and with Bordeaux mixture have not been found to vary greatly from those from the untreated check plots over a period of several years.

13. Copper-containing fungicides, particularly Bordeaux mixture, gave approximately 90 percent control of leafhoppers on potatoes.

14. Copper-containing fungicides gave better control of late blight in some instances than did zineb.

15. Potatoes treated throughout the season with copper-containing fungicides were more sensitive to injury by marginal frosts than were those sprayed with zinc-containing compounds.

16. Copper naphthenate applied as an aerosol gave excellent control of late blight in the one experiment where it was used. The same material formulated in non-toxic oils was usually phytotoxic.

17. Cop-O-Zinc gave slightly better disease control and higher yields in most instances than did Tribasic (which contained no zinc).

18. Zineb has consistently given the best results of any of the potato fungicides that have been tested in Ohio during the past 13 years. It has been equally effective whether the spray mixture has been prepared from the wettable powder or by adding solubilized zinc sulfate to nabam.

19. Ferbam, the first of the dithiocarbamates to be tested on potatoes in Ohio, seemed an improvement over many of the potato fungicides available in 1941 to 1943, but it was soon replaced on that crop by ziram, zineb, and maneb. Later tests with ferbam have consistently shown it to be inferior to zineb on potatoes.

20. Various ziram formulations consistently failed to give as good control of early blight as did zineb, with the possible exception of Methasan slurry, and their control of late blight was much poorer than that furnished by zineb.

21. Dust formulations of most fungicides have not equalled spray mixtures in the control of potato diseases when both were applied at the same rate per acre. However, dust mixtures used in excess have given excellent disease control and yields in some instances. Zerlate (ziram) formulated as a dust has more nearly equalled the results obtained by spray applications than any other fungicide so far tested.

22. The use of different materials (talcs, clays, pyrophyllites, etc.) as diluents in dust formulations had comparatively little effect on the effectiveness in disease control by the fungicidal ingredient.

23. Ziram prepared as a paste or slurry has been more effective in the control of early blight than as a wettable powder. The tank-mix formulation prepared by adding solubilized zinc sulfate to sodium dimethyl dithiocarbamate has also out-performed the wettable powder formulation.

24. Zinc-containing organic fungicides such as ziram and zineb interfere much less with the normal blooming of potatoes than do copper-containing materials such as Bordeaux mixture and the fixed coppers.

25. Maneb formulated as a wettable powder is a near equal of zineb on potatoes, but since it is slightly more costly, it is not being recommended as a replacement for zineb on Ohio potatoes, as it is on tomatoes.

26. Although zineb is judged to be equally effective in the control of potato diseases as a wettable powder and in a tank-mix formulation, the wettable powder form of maneb has given considerably better results than the product obtained when solubilized manganese sulfate is added to nabam just before it is to be applied.

27. Copper ethylene bis dithiocarbamate is comparable to the zinc and manganese forms in early blight control. Replacing part of the zinc sulfate with copper sulfate in the preparation of tank-mix zineb gave good results in limited tests.

28. Parathion has given better control of white flies on potatoes than any other insecticide so far tested.

29. Systox, a systemic insecticide, has given good control of leafhoppers and aphids on potatoes, and poor control of flea beetles. Its residual toxicity is approximately three times that of parathion.

30. Parathion, heptachlor, toxaphene, aldrin, and dieldrin gave good control of DDT-resistant flea beetles. Dieldrin was superior in this respect to the other four materials.

31. Calcium arsenate and methoxychlor have been found to favor an increase in aphid populations on potatoes, whereas, parathion, malathion, and Systox keep them under control, with other insecticides such as DDT more or less intermediate in this respect.

32. In using concentrate formulations for the control of potato diseases 10 gallons of a 16X formulation has failed to equal the performance of higher gallonages, and 20 p.s.i. may be too little to use in applying 40 gallons per acre of a 4X formulation.

33. In most instances the application of 4X formulations at 40 gallons per acre has given results in disease and insect control, and yield, that were closely comparable with those obtained with 160 g.p.a. of an "X" formulation.

34. Pressure-volume variations, with their accompanying variations in droplet size, gave surprisingly similar results in terms of disease and insect control when the same quantity of fungicide was applied per acre all the way from 40 to 200 p.s.i. and from 30 to 160 gallons of water per acre.

35. In spraying potatoes with an airplane the use of 15 g.p.a. of a 10X formulation gave considerably better coverage of the foliage than did 10 g.p.a. of a 15X or 5 g.p.a. of a 30X concentrate.

36. Adjuvants, such as wetting and adhesive agents, have not (with the exception of p.e.p.s.) appreciably improved the degree of disease and insect control commonly obtained with most of the better pesticides used in these experiments.

37. P.e.p.s., a mild fungicide in its own right, has been found to consistently increase the effectiveness of the fixed coppers, and to a lesser extent of numerous organic fungicides, when formulated with the different compounds as an adhesive.

38. "Bonding" of the fungicidal ingredient did not materially influence its effectiveness in disease control.

39. Potato varieties most susceptible to injury by diseases and insects responded more favorably to treatment by a fixed copper plus DDT formulation than did varieties more resistant to leafhoppers and late blight.

40. All of the fungicides so far tested have failed to give any worthwhile control of bacterial stalk rot of potato.

41. Finally, the most important result obtained from the 13 years of potato spraying reported here has been the establishment of the superiority of zineb and DDT for use on Ohio potatoes, and more recently the need for a supplemental insecticide such as dieldrin to control DDT—resistant flea beetles.

LITERATURE CITED

1. DeLong, D. M. 1929. The role of Bordeaux mixture as a leafhopper insecticide. Jour. Econ. Ent. 22: 345-353.
2. Wilson, J. D., and H. A. Runnels. 1933. Some detrimental effects of spraying tomatoes with Bordeaux mixture. Ohio Agr. Exp. Sta. Bimo. Bull. 18: 4-15.
3. Huber, L. L., and J. P. Sleesman. 1934. Technique in field experimentation in Entomology. I. Some principles involved in a well-planned experiment. Jour. Econ. Ent. 27: 1166-1170.
4. Tilford, P. E. 1940. Ohio potato diseases. Ohio Agr. Exp. Sta. Bull. 615: 1-35.
5. Irons, Frank. 1943. A laboratory study of crop duster problems. Agric. Engr. 24: 383-384.
6. Sleesman, J. P., and J. D. Wilson. 1943. Comparison of fixed coppers and Bordeaux mixture in the control of insects and diseases of muck-grown Irish Cobbler potatoes. Ohio Agr. Exp. Sta. Bimo. 28: 173-183.
7. Sleesman, J. P. 1943. Potato spraying and dusting to improve yields. Proc. Ohio Veg. & Potato Growers Assoc. 28: 18-21.
8. Gui, H. L., J. P. Sleesman, and J. D. Wilson. 1944. Spray intervals and potato yields. Proc. Ohio Veg. & Potato Growers Assoc. 29: 104-109.
9. Wilson, J. D. 1944. Ten years of carrot spraying with various copper-containing spray materials. Ohio Agr. Exp. Sta. Bimo. Bull. 29: 63-73.
19. Wilson, J. D. 1944. The control of celery blights with Bordeaux, the fixed coppers with and without sulfur, and Fermate. Ohio Agr. Exp. Sta. Bimo. Bull. 29: 95-109.
11. Wilson, J. D. 1944. Spray and dust formulas for the control of vegetable diseases. Proc. Ohio Veg. & Potato Growers Assoc. 29: 49-58.
12. Sleesman, J. P., H. L. Gui, and J. D. Wilson. 1945. DDT and other new materials for spraying potatoes. Proc. Ohio Veg. & Potato Growers Assoc. 30: 140-147.
13. Wilson, J. D., and J. P. Sleesman. 1945. Possible influences of new organic pesticides on experimental test procedure. Ohio Agr. Exp. Sta. Bimo. Bull. 30: 27-30.
14. Sleesman, J. P., and John Bushnell. 1945. The yield response of several commercially important potato varieties to the application of Bordeaux mixture. Ohio Ogr. Exp. Sta. Bimo. Bull. 30· 73-75.

15. Wilson, J. D. 1945. Organic fungicides and the control of vegetable diseases in Ohio. Ohio Agr. Exp. Sta. Bimo. Bull. 30: 49-61.
16. Wilson, J. D., and J. P. Sleesman. 1946. Potato spraying experiments in 1945. Proc. Ohio Veg. & Potato Growers Assoc. 31: 193-208.
17. Sleesman, J. P., and J. D. Wilson. 1946. The effect of DDT on potato insect populations. Proc. Ohio Veg. & Potato Growers Assoc. 31: 182-192.
18. Wilson, J. D., and J. P. Sleesman. 1946. Spray materials and the blooming of potatoes. Amer. Potato Jour. 23: 57-64.
19. Wilson, J. D. 1946. Use of fixed coppers on vegetables. Agr. Chem. 1: 32-34.
20. Glaves, A. 1947. A new dust feed mechanism for crop dusters. Agr. Engr. 28: 551-552.
21. Wilson, J. D. and J. P. Sleesman. 1947. Some of the newer pesticides damage plants. Ohio Agr. Exp. Sta. Bimo. Bull. 32: 58-63.
22. Wilson, J. D. 1947. Relation between spray treatments and frost damage to potatoes and tomatoes. Ohio Agr. Exp. Sta. Bimo. Bull. 32: 77-82.
23. Sleesman, J. P., and J. D. Wilson. 1947. Potato spraying experiments in 1946. Proc. Ohio Veg. & Potato Growers Assoc. 32: 125-132.
24. Wilson, J. D., and J. P. Sleesman. 1947. The differential response of potato varieties to spraying with DDT plus a fixed copper. Amer. Potato Jour. 24: 260-266.
25. Heuberger, J. W. 1948. Organic and copper fungicides for potatoes and their compatibility with DDT. Del. Agr. Exp. Sta. Bull. 274: 1-18.
26. Wilson, J. D., and J. P. Sleesman. 1948. The influence of various pesticides on the growth and transpiration of cucumber, tomato, and potato plants. Ohio Agr. Exp. Sta. Bull. 676: 1-23.
27. Wilson, J. D., and J. P. Sleesman. 1948. Potato spraying experiments in Ohio in 1947. Proc. Ohio Veg. & Potato Growers Assoc. 33: 74-82.
28. Thurston, H. W., J. G. Leach, and J. D. Wilson. 1948. Chromates as potato fungicides. Amer. Potato Jour. 25: 406-409.
29. Wilson, J. D., and J. P. Sleesman. 1949. New fungicides and insecticides on potatoes. Proc. Ohio Veg. & Potato Growers Assoc. 34: 96-102.
30. Sleesman, J. P., and J. D. Wilson. 1950. New insecticides and fungicides for spraying potatoes. Proc. Ohio Veg. & Potato Growers Assoc. 35: 142-149.
31. Wilson, J. D. 1950. Preliminary results with low-gallonage sprays for vegetable disease control. Proc. Ohio Veg. & Potato Growers Assoc. 35: 86-96.
32. Wilson, J. D. 1950. Controlling diseases of vegetable crops with organic fungicides. Agr. Chem. 5 (7): 32-33.

33. Wilson, J. D., and J. P. Sleesman. 1951. Disease and insect control on potatoes in Ohio in 1950. Amer. Potato Jour. 28: 632-638.

34. Wilson, J. D., and J. P. Sleesman. 1951. Disease and insect control on potatoes in 1950. Proc. Ohio Veg. & Potato Growers Assoc. 36: 124-133.

35. Sleesman, J. P. 1951. New insecticides for vegetable insect control. Proc. Ohio Veg. & Potato Growers Assoc. 36: 90-109.

36. Sleesman, J. P., and J. D. Wilson. 1952. Up to date on insect and disease control on potatoes. Proc. Ohio Veg. & Potato Growers Assoc. 37: 94-97.

37. Wilson, J. D. 1952. The field testing of fungicides for vegetable disease control. Phytopath 41: 1050-1058.

38. Wilson, J. D. 1952. Comparative effectiveness in the control of early blight on potatoes and tomatoes of differently formulated dithiocarbamates. Phytopath 42: 25. (abst.)

39. Wilson, J. D. 1953. Wettable powder versus tank-mix dithiocarbamates on potatoes and tomatoes in Ohio. Ohio Agr. Exp. Sta. Res. Circ. 9: 1-21.

40. Sleesman, J. P. 1953. Control of insects attacking the foliage of potato. Amer. Potato Jour. 30 (7): 165-174.

41. Sleesman, J. P. 1954. Potato insect control. Proc. Ohio Veg. & Potato Growers Assoc. 39: 110-114.

42. Sleesman, J. P., and J. D. Wilson. 1955. Potato pest control for 1954. Proc. Ohio Veg. & Potato Growers Assoc. 40: 110-115.

43. Sleesman, J. P. 1955. Improved practices in potato pest control. Market Grower's Jour. 84 (4): 6, 7, 30.

44. Wilson, J. D., and J. P. Sleesman. 1956. Depression of potato yields by Bordeaux mixture during a dry summer. Amer. Potato Jour. 33: 177-184.

45. Wilson, J. D., J. P. Sleesman, and J. E. Henry. 1956. Airplane spraying tested on potato insect and disease control. Ohio Farm and Home Research 41 (Mar.-Apr.): 20-22.

46. Wilson, J. D. 1956. Facts you should know about air-blast spraying. Amer. Veg. Grower 4 (5) 9, 32-33.

Table I. Effect of various fungicides on foliage condition, leafhopper populations, and yield of potatoes at McGuffey in 1942.

Materials	Formulas	Yield in bushels per acre	Nymphs per 100 leaves	Percent of foliage dead on Aug. 10
1. Untreated		375	816	79
2. Bordeaux mixture	10-5-100	529	154	30
3. Tribasic + bentonite + talc	14-14-72	445	282	55
4. Copper A + bentonite + talc	14-14-72	493	174	44
5. COC-S + bentonite + talc	14-14-72	511	106	43
6. Cuprocide + bentonite + talc	8-14-78	508	124	34
7. Fermate + talc	10-90	585	124	14
L.S.D. at 5% level		70	107	

Table 3. The effect of length of spray interval and the use of calcium arsenate on potato yields and flea beetle populations at Wooster in 1943.

Materials	Formulas	Yield in bushels per acre — Spray interval in days			Flea beetle punctures per sq. in. of leaf area (Avg. 3 dates) — Spray interval in days		
		10	7	3.5	10	7	3.5
Bordeaux	8-12-100	120	146	209	71	50	27
Bordeaux + Cal. arsenate	8-12-4-100	128	173	241	62	37	13
Copper A	4-100	100	114	176	87	67	53
Copper A + Cal. arsenate	4-4-100	149	200	206	61	45	15
L.S.D. at 5% level		16					

Table 2. Results obtained at Wooster in 1943 by spraying potatoes at different application intervals, by varying the amount of lime in the Bordeaux formula, and by the use of adhesive materials with both Bordeaux and COC-S.

Materials	Formulas	Yield in bushels per acre	Leafhopper nymphs per 10-leaf samples	Flea beetle punctures per 1-cm. leaf disc	Percent Foliage Dead on Aug. 1	Average copper deposit after rains in μg/cm^2 of leaf surface
1. Bordeaux 10 days	8-12-100	156	2.2	12.8	50	5.3
2. " 5 days	8-12-100	176	1.0	8.8	34	11.6
3. " 5 days	4-6-100	158	3.0	9.8	48	6.5
4. "	8-16-100	152	2.2	13.4	42	5.4
5. " + Cal. arsenate	8-12-4-100	185	2.0	13.0	36	4.0
6. " + Volck	8-12-1-100	146	3.6	11.8	54	6.1
7. " + Orthex (liquid)	8-12-¼-100	149	4.0	13.8	52	6.3
8. COC-S 10 days	4-100	149	1.2	17.8	58	1.5
9. " 5 days	4-100	156	0.0	12.4	46	3.1
10. " 5 days	2-100	148	0.6	17.2	50	2.0
11. " + lime	4-4-100	142	1.8	15.8	56	1.5
12. " + Cal. arsenate	4-4-100	176	0.2	12.8	44	1.4
13. " + bentonite	4-16-100	135	2.0	12.0	56	6.9
14. " + Orthex (liquid)	4-1/4-100	125	3.8	18.0	68	1.4
15. " + Sulfur-W	4-8-100	133	2.2	15.2	56	1.0
16. COC-S + talc (on dry foliage)	14-86	111	17.0	18.4	64	0.2
17. " + " (on wet foliage)	14-86	122	8.2	17.6	64	0.5
18. Fermate	2-100	118	53.2	17.8	64	—
19. Bordeaux	8-4-100	113	8.8	15.6	64	3.9
20. No treatment		89	70.2	23.6	84	—
L.S.D. at 5% level		17				

Table 4. Potato yields at McGuffey in 1943 when the plants were sprayed and dusted with various materials and at different intervals between treatments.

	Materials		Formulas	Yield in bushels per acre	Flea beetle punctures per 1-cm. leaf disc	Percent foliage dead on Aug. 20
1.	Bordeaux		8-12-100	476	9.3	36
2.	"	5 days	8-12-100	478	9.7	32
3.	"	5 days	4-6-100	419	10.8	37
4.	"		8-16-100	482	9.8	39
5.	"	+ Cal. arsenate	8-12-4-100	409	9.6	49
6.	"	+ Volck	8-12-1-100	429	9.7	42
7.	"	+ Orthex	8-12-¼-100	446	10.6	43
8.	COC-S		4-100	456	10.8	46
9.	"	5 days	4-100	434	10.9	42
10.	"	5 days	2-100	399	11.7	49
11.	"	+ Lime	4-4-100	418	12.2	54
12.	"	+ Cal. arsenate	4-4-100	455	11.4	47
13.	"	+ bentonite	4-16-100	306	10.9	44
14.	"	+ Orthex	4-1/4-100	365	12.5	60
15.	"	+ Sulfur	4-8-100	443	11.2	51
16.	"	+ talc (on dry foliage)	14-86	477	9.9	36
17.	"	+ " (on wet foliage)	14-86	460	9.7	35
18.	Fermate		2-100	369	10.3	44
19.	Bordeaux		8-4-100	444	10.0	42
20.	HE-175 (Dithane)		2-100	518	10.8	39
21.	Fermate		10-90	407	9.6	42
22.	COC-S + Sulfur		14-20-66	435	8.6	38
23.	Tribasic		14-86	424	8.8	38
24.	"	+ Sulfur	14-20-66	423	9.8	44
25.	Cuprocide		8-92	437	10.2	34
26.	Cuprocide + Sulfur		8-20-72	449	9.1	32
27.	No treatment			271	11.2	64
	L.S.D. at 5% level			75		

Table 5. Influence of various treatments on yield, foliage condition, number of flea beetle punctures, and leafhopper populations, on potatoes grown at Wooster in 1944.

Materials	Formulas	Yield in bushels per acre	Flea beetle punctures in sample of 10 leaves	Leafhopper nymphs per 100 leaves	Percent of foliage dead on July 26
1. Bordeaux mixture	8-8-100	112	154	41	66
2. " "	8-12-100	112	153	20	67
3. " " + calcium arsenate	8-8-4-100	113	91	27	62
4. Bordeaux 5 days	8-8-100	117	83	5	51
5. " 5 days	4-4-100	113	156	31	59
6. COC-S	4-100	101	284	122	72
7. " 5 days	4-100	113	182	39	62
8. " 5 days	2-100	100	194	79	70
9. " + calcium arsenate	4-4-100	97	210	176	73
10. Fermate + $ZnSO_4$ + lime	2-2-1-100	100	218	538	63
11. Dithane Z-78	2-100	92	315	793	85
12. " + $ZnSO_4$ + lime	2-1½-½-100	86	288	708	81
13. " + LB72	2-2½-100	89	301	617	87
14. Methasan + calcium arsenate	2-4-100	116	213	390	61
15. Puratized + calcium arsenate	1-4-100	88	225	560	65
16. COC-S + DDT-W	4-1-100	126	98	0	43
17. COC-S + calcium arsenate + talc 40#/A	15-10-75	100	256	515	72
18. COC-S + calcium arsenate + talc 60#/A	15-10-75	100	272	212	64
19. COC-S + calcium arsenate + talc 80#/A	15-10-75	103	275	138	71
20. No treatment		75	430	1388	96
L.S.D. at 5% level		11			

Table 6. Influence of timing interval, and various insecticides and fungicides, on the yield, insect populations, and defoliation of potatoes at Wooster in 1944.

Materials	Formulas	Spray interval in days	Yield in bushels per acre	Flea beetle punctures in 1.5 cm. leaf discs	Leafhopper nymphs per 10 leaflets
1. Bordeaux mixture	8-12-100	3	170	2.8	0.2
2. " "	8-12-100	6	164	7.7	3.0
3. " "	8-12-100	9	150	9.7	5.0
4. Bordeaux + calcium arsenate	8-12-4-100	3	198	0.3	0.0
5. " + " "	8-12-4-100	6	179	3.8	0.8
6. " + " "	8-12-4-100	9	163	5.0	1.8
7. Copper A	4-100	3	163	4.5	2.2
8. " A	4-100	6	156	12.2	8.2
9. " A	4-100	9	142	8.3	1.0
10. Copper A + calcium arsenate	4-4-100	3	197	3.0	0.4
11. " + " "	4-4-100	6	179	9.1	5.0
12. " + " "	4-4-100	9	179	6.6	9.0
13. Copper A + DDT-50W	4-1-100	6	229	1.1	1.2
14. Fermate + "	2-1-100	6	240	2.7	0.0
15. DDT-50W	1-100	6	225	3.4	0.0
16. LB72	2½-100	6	120	14.4	5.0
17. HE175 + $ZnSO_4$ + lime	2-1-½-100	6	144	17.2	9.6
18. " + " + " + LB72	2-1-½-2½-100	6	120	16.4	5.2
19. " + " + LB72 + calcium arsenate	2-1-½-2½-4-100	6	191	14.9	5.0
20. LB71 + talc	14-86	6	94	16.8	2.6
21. " + " + calcium arsenate	14-10-76	6	148	16.8	6.2
22. Copper A + LB71 + talc	15-14-71	6	150	13.5	8.6
23. " + " + calcium arsenate + talc	15-14-10-61	6	166	14.4	4.4
24. Fermate + LB71 + calcium arsenate + talc	10-14-10-66	6	151	13.4	3.8
L.S.D. at 5% level			42		

Table 7. The influence of various potato treatments on yields, flea beetle injury, leafhopper populations, and foliage condition at McGuffey in 1944.

Materials	Formulas	Yield in bushels per acre	Flea beetle punctures in a sample of 10 leaves	Leafhopper nymphs per 100 leaves	Percent of foliage dead on Aug. 15
1. Bordeaux mixture	8-8-100	477	90	442	38
2. " "	8-12-100	448	81	498	46
3. " + cal. arsenate	8-8-4-100	488	51	348	40
4. " (5days)	**8-8-100**	496	35*	260	31
5. " (5days)	4-4-100	471	45	264	37
6. " (3X weekly)	8-8-100	436	5	68	25
7. COC-S	4½-100	480	147	124	46
8. " (5 days)	4½-100	478	91	34	39
9. " (5 days)	2¼-100	469	155	130	44
10. " + cal. arsenate	4½-4-100	464	76	150	52
11. " + Niakil	4½-4-100	495	39	110	49
12. " + $ZnSO_4$ + lime	4½-2-1-100	455	103	274	40
13. Fermate	2-100	317	155	1234	76
14. " (5 days)	2-100	316	104	864	68
15. " + cal. arsenate	2-4-100	357	70	958	74
16. " + DDT-W	2-1-100	599	39	0	24
17. " + $ZnSO_4$ + lime	2-2-1-100	555	104	12	26
18. " + LB72	2-2½-100	501	165	318	46
19. " + Sulfur-W	2-8-100	389	104	466	60
20. Dithane	2-100	438	160	286	80
21. " (5 days)	2-100	440	151	166	51
22. " + cal. arsenate	2-4-100	397	83	402	81
23. " + $ZnSO_4$ + lime	2-2-1-100	451	181	286	61
24. " + LB72	2-2½-100	446	181	136	55
25. DDT-W	1-100	571	47	0	44
26. " + COC-S	1-4½-100	570	36	0	28
27. LB72	2½-100	493	127	16	53
28. " + COC-S	2½-4½-100	551	99	26	40
29. Methasan + cal. arsenate	2-4-100	546	61	26	31
30. Puratized + " "	1-4-100	391	60	554	42
31. Metallic copper	2½-100	415	154	658	65
32. Copper A	4½-100	399	107	516	63
33. COC-S + cal.ars. + talc 40#/A	15-10-75	390	105	238	77
34. " + " " + " 60#/A	15-10-75	449	95	86	60
35. " + " " + " 80#/A	15-10-75	483	128	104	53
36. COC-S + talc	15-85	461	209	136	62
37. LB71 Dust 60#/A		436	141	156	82
38. COC-S + LB71 + talc 60#/A	15-14-71	494	145	84	57
39. Fermate + talc 60#/A	10-90	461	111	160	46
40. No treatment		316	208	1544	97
41. COC-S	4½-100	537	71	68	30
42. Tracel	4-100	400	84	1054	74
43. " + COC-S	4-4½-100	520	30	94	32
44. Esminel + lime	8-8-100	439	53	98	45
45. " + " + COC-S	8-8-4½-100	449	40	70	32
46. Bordeaux + DDT-W	8-8-1-100	589	42	0	15
L.S.D. at 5% level		52			

Table 8. Influence of various insecticides and fungicides on the control of flea beetles, leafhoppers, and aphids, and on the resulting potato yields at Marietta in 1944.

Materials	Formulas	Yield in bushels per acre	Flea beetle punctures in 1.5 cm. leaf disc	Leaf-hopper nymphs per 10 leaflets	Relative Aphid population
1. No treatment		218	271	240	—
2. DDT-50W	1-100	356	48	10	13
3. LB72	2½-100	272	192	70	21
4. Bordeaux	8-12-100	298	185	80	17
5. Copper A	4-100	241	194	180	20
6. HE-175 + $ZnSO_4$ + lime	2-1-½-100	264	212	80	16
7. Fermate + DDT	4-1-100	441	76	0	15
8. Copper A + DDT	4-1-100	413	61	0	14
9. Bordeaux + Cal. arsenate	8-12-4-100	301	145	20	30
10. Copper A + " "	4-4-100	296	187	50	28
11. HE-175 + $ZnSO_4$ + lime + LB72	2-1-½-2½-100	283	191	60	18
12. " + " + " + " + Cal. arsenate	2-1-½-2½-4-100	287	162	60	25
13. Copper + lime Dust	20-80	291	189	60	20
14. Copper + " + Cal. arsenate	20-70-10	304	179	80	22
15. Copper A + bentonite + talc	14-15-71	268	206	60	20
16. Copper A + " + Cal. arsenate + talc	14-15-10-61	260	179	70	30
17. LB71 + talc	14-86	277	202	20	20
L.S.D. at 5% level		68			

Table 9. Comparative disease and insect control when potatoes were sprayed with various fungicides used with calcium arsenate or DDT at Wooster in 1945.

Materials	Formulas	Yield in bushels per acre	Flea beetle punctures per leaflet	Leafhopper nymphs per 100 leaves	Aphids per leaf	Number of blossom clusters per 100 plants	Percent of foliage dead on July 26
1. Bordeaux + Cal. arsenate	8-8-4-100	336	12	50	1360	67	41
2. Tribasic + " "	4-4-100	315	6	60	1392	88	51
3. " + " " + Zn-lime	4-4-1-½-100	350	3	230	1752	131	35
4. COC-S + Cal. arsenate	4½-4-100	333	5	50	1144	85	42
5. 3-way COC-S + Cal. arsenate	6-4-100	325	20	530	1232	92	51
6. Zerlate + Cal. arsenate	2-4-100	381	4	170	1760	136	36
7. Karbam W. + Cal. arsenate	2-4-100	352	4	700	2160	117	42
8. 4-way Carbamate + Cal. arsenate	2-4-100	387	4	690	2016	155	37
9. Fermate + Cal. arsenate	2-4-100	331	4	850	1528	152	44
10. Ni carbamate + Zn-Lime	2-1-½-100	391	19	850	136	176	38
11. Dithane D-14 + " "	4-1-½-100	380	22	470	64	164	35
12. " + Zn-Lime + LB72	4-1-½-3-100	389	48	160	32	188	34
13. Z39	1½-100	444	47	0	24	160	46
14. DDT (10 days)	3-100	484	2	0	0	201	30
15. " (20 days)	3-100	475	4	0	0	153	39
16. Bordeaux + DDT	8-8-3-100	523	4	0	0	120	21
17. Tribasic + "	4-3-100	506	1	0	0	104	28
18. COC-S + "	4½-3-100	485	2	0	0	109	30
19. Zerlate + "	2-3-100	529	1	0	0	231	19
20. Fermate + "	2-3-100	522	3	0	0	183	25
21. Dithane + "	4-3-100	450	1	0	0	198	29
22. Sulfur-W + "	8-3-100	513	6	0	0	200	27
23. Dithane + Z39	4-1½-100	393	13	22	30	157	40
24. DDT + EM talc 50#/A	3-97	489	2	0	0	202	28
25. " + " 75#/A	3-97	488	2	0	0	168	28
26. No treatment		321	53	900	25	130	56
L.S.D. at 5% level		40					

Table 10. Comparative effectiveness of various formulations of DDT when used on Cobbler potatoes at Wooster in 1945.

Treatments	Formulas	Yield in bushels per acre	Flea beetle* punctures per sq. inch of leaf area	Blossom clusters per 100 plants	Percent of foliage dead on July 25
Section A					
1. Bordeaux + DDT	8-8-3-100	529	2	88	30
2. " + "	6-6-3-100	540	2	108	29
3. " + "	4-4-3-100	524	2	129	32
4. Bordeaux and DDT alternating		542	7	111	31
5. Bordeaux with DDT added to alternate application		547	4	85	27
L.S.D. at 5% level		23			
Section B					
6. DDT 1/16 lb.	1/4-100	466	15	119	47
7. " 1/8 lb.	1/2-100	517	10	159	43
8. " 1/4 lb.	1-100	517	3	163	41
9. " 1/2 lb.	2-100	521	1	167	37
10. " 3/4 lb.	3-100	529	1	183	38
11. " 1 lb.	4-100	532	1	162	41
L.S.D. at 5% level		27			
Section C					
12. Z39	1½-100	498	6	168	44
13. DDT - Geigy AK40	2-100	502	1	195	39
14. " - S & W (50%)	1½-100	535	1	220	37
15. " with bentonite	1½-100	513	1	184	38
16. " with clay	1½-100	509	1	187	40
17. " with talc	1½-100	539	1	194	40
18. " with lime	1½-100	499	2	176	42
19. DDT (DuPont No. 3)	1½-100	504	2	179	43
20. Methoxychlor	3-100	471	2	197	46
21. BHC	3 3/4-100	504	2	160	46
22. DDT - USDA Emulsion 6%	2½-100	504	1	144	49
23. " - DuPont " 25%	2-100	511	1	167	43
24. " - Geigy " 20%	2½-100	512	1	191	40
25. " - US Rubber " 33%	1½-100	476	1	103	45
26. DDT DuPont No. 1	1½-100	519	1	184	40
L.S.D. at 5% level		36			

*Leafhoppers and aphids were virtually absent in these plots.

Table II. Comparative effectiveness of various fungicides and insecticides in the control of diseases and insects, respectively, on potatoes grown at Marietta in 1945.

Treatments	Formulas	Yield in bushels per acre	Flea beetle punctures per 10 leaves	Leafhopper nymphs per 100 leaves	Aphids per 10 leaves	Leaves with Late blight per 10 plants	Percent foliage dead on July 11
1. Bordeaux + Ca. arsenate	8-12-4-100	324	75	47	240	57	31
2. COC-S + " "	4-4-100	343	70	29	305	72	32
3. Zerlate + " "	2-4-100	369	72	75	335	92	34
4. Fermate + " "	2-4-100	317	71	64	285	70	38
5. Dithane + $ZnSO_4$ + lime + Ca. arsenate	4-1-½-4-100	326	66	47	245	80	33
6. Dithane + $ZnSO_4$ + lime + LB72	4-1-½-3-100	314	68	47	265	88	36
7. Dithane + Z 39	4-1½-100	298	82	1	120	125	39
8. Z 39	1½-100	258	83	16	130	130	51
9. Bordeaux + DDT	8-8-3-100	407	12	2	70	56	22
10. COC-S + "	4-3-100	394	18	1	105	73	26
11. Zerlate + "	2-3-100	481	10	0	65	78	30
12. Fermate + "	2-3-100	409	14	1	60	81	39
13. Dithane + "	4-3-100	379	18	4	120	100	40
14. Bordeaux (8-12-100) and DDT (3-100) alternating		435	31	7	30	66	24
15. Zerlate (2-100) and DDT (3-100) alternating		377	50	2	470	81	29
16. DDT + talc	3-97	319	20	1	30	130	47
17. No treatment		284	198	760	400	174	67
LSD at 5% level		73					
Averages 5 fung. + Ca. Ars.		336	71	52	282	74	34
Averages " " + DDT		414	14	2	84	78	31

Table 12. Comparative performance of various fungicides and insecticides in the control of diseases and insects, respectively, at McGuffey in 1945.

Treatments	Formulas	Yield in bushels per acre	Flea beetle punctures per leaflet	Leafhopper nymphs per 100 leaves	Aphids per leaf	Percent foliage dead on Aug. 15
1. Bordeaux	8-8-100	444	14	80	35	66
2. " + Ca. arsenate	8-8-4-100	404	10	73	300	54
3. Tribasic + " "	4-4-100	325	14	105	140	51
4. " + " " + $ZnSO_4$ + lime	4-4-1-½-100	301	10	91	170	43
5. COC-S + Ca. arsenate	4½-4-100	339	12	59	140	50
6. 3-way COC-S + Ca. arsenate	6-4-100	382	11	49	210	54
7. Zerlate + Ca. arsenate	2-4-100	337	16	73	220	56
8. Karbam W + " "	2-4-100	362	17	112	280	54
9. 4-way Carbamate + Ca. arsenate	2-4-100	257	9	168	230	44
10. Methasan + Ca. arsenate	2-4-100	333	10	115	240	49
11. Fermate + " "	2-4-100	284	14	224	190	41
12. Ni carbamate + $ZnSO_4$ + lime	2-1-½-100	373	19	67	35	54
13. Dithane + $ZnSO_4$ + lime	4-1-½-100	351	11	180	30	56
14. " + " + " + LB72	4-1-½-3-100	437	22	129	40	56
15. Tenncop + Ca. arsenate	3-4-100	329	20	81	140	49
16. Bordeaux + DDT	8-8-3-100	502	9	0	0	68
17. " + "	6-6-3-100	490	8	0	1	66
18. " + "	4-4-3-100	463	6	0	10	63
19. " (8-8-100) and DDT (3-100) alternating		360	9	0	6	56
20. " (8-8-100) and Bordeaux + DDT (8-8-3-100) alternating		482	7	0	8	65
21. Sulfur-W +DDT	8-3-100	460	5	0	0	69
22. Tribasic + "	4-3-100	458	7	0	0	64
23. COC-S + "	4½-3-100	465	7	0	0	61
24. Fermate + "	2-3-100	470	14	0	1	65
25. Dithane + "	4-3-100	462	17	0	0	64
26. Dithane + Z 39	4-1½-100	421	14	0	0	60
27. Zerlate + DDT	2-3-100	508	6	0	9	73
28. Zerlate 2-100 and Zerlate + DDT Alternating		548	6	0	7	71
29. No treatment		227	20	322	35	89
Averages 5 fung. + Ca. Ars.		351	13	98	166	53
Averages " " + DDT		479	9	0	2	66

Table 13. Comparative effectiveness of differently formulated DDT mixtures in the control of potato insects at McGuffey in 1945.

Treatments	Formulas	Yield in bushels per acre	Flea beetle punctures per leaflet	Leafhopper nymphs per 100 leaves	Aphids per leaf	Percent foliage dead on Aug. 15
1. Z 39	1½-100	359	7	0	5	41
2. DDT (10 days)	3-100	401	6	0	0	41
3. DDT (15 days)	3-100	390	7	0	10	41
4. DDT (20 days)	3-100	393	10	0	0	42
5. DDT 1/16 lb.	¼-100	515	10	0	1	30
6. DDT 1/8 lb.	½-100	562	9	0	10	26
7. DDT 1/4 lb.	1-100	513	7	0	5	26
8. DDT 1/2 lb.	2-100	575	9	0	1	26
9. DDT 3/4 lb.	3-100	578	9	0	3	24
10. DDT 1 lb.	4-100	594	10	0	6	24
11. DDT DuPont #1 (50%)	1½-100	551	12	0	0	26
12. DDT DuPont #3 (50%)	1½-100	525	12	0	3	26
13. DDT DuPont #4 (50%)	1½-100	519	14	0	3	27
14. DDT Geigy AK40	2-100	550	14	0	10	29
15. DDT S & W (50%)	1½-100	513	14	0	9	27
16. DDT + bentonite (50%)	1½-100	522	9	0	5	29
17. DDT + clay (50%)	1½-100	492	12	0	4	30
18. DDT + talc (50%)	1½-100	522	9	0	6	27
19. DDT + lime (50%)	1½-100	496	14	0	3	34
20. DDT-USDA Emulsion 6%	2½-100	372	12	0	6	40
21. DDT-DuPont Emulsion 25%	2-100	359	9	0	4	40
22. DDT-Geigy Emulsion 20%	2½-100	358	9	0	1	44
23. DDT-US Rubber Emulsion 33.3%	1½-100	345	9	0	18	46
24. DDT + EM Talc 50#/A	3-97	406	9	0	22	40
25. DDT + EM Talc 75#/A	3-97	367	5	0	15	40
26. Methoxychlor 25%	3-100	418	4	0	12	37
27. BHC 20%	3 3/4-100	363	5	0	2	37
28. No treatment		296	9	91	17	49
L.S.D. at 5% level		73				

Table 14. Comparative effectiveness of differently formulated DDT preparations and of calcium arsenate and DDT as a wettable powder (on potato insect control) when used with different fungicides on Sebago potatoes grown at Wooster in 1945.

Treatments	Formulas	Yield in bushels per acre	Flea beetle punctures per leaflet	Aphids per leaf	Percent foliage dead on Aug. 20
1. Z 39	1½-100	341	48	77	39
2. Methoxychlor	3-100	335	17	68	37
3. BHC 20%	4-100	370	23	6	34
4. DDT-DuPont #1	1½-100	396	15	4	35
5. " - " #3	1½-100	413	18	31	38
6. DDT-DuPont #4	1½-100	441	11	9	30
7. " -Geigy	2-100	450	14	4	31
8. " -S & W	1½-100	374	25	4	35
9. DDT 1/4 lb.	1-100	444	28	1	31
10. " 1/2 lb.	2-100	445	25	4	32
11. " 3/4 lb.	3-100	393	16	2	32
12. DDT DuPont Emulsion	2-100	429	27	4	29
13. " Geigy "	2½-100	388	19	18	41
14. DDT + talc	3-97	363	12	50	37
15. Bordeaux + Ca. arsenate	8-8-4-100	208	14	308	52
16. COC-S + Ca. arsenate	4½-4-100	241	12	345	64
17. Zerlate + Ca. arsenate	2-4-100	218	11	245	57
18. Fermate + " "	2-4-100	229	13	253	64
19. Dithane + $ZnSO_4$ + lime + Ca. arsenate	4-1-½-4-100	218	8	207	60
20. Dithane + $ZnSO_4$ + lime + LB72	4-1-½-3-100	260	28	170	50
21. Bordeaux + DDT	8-8-3-100	320	8	33	42
22. " + "	6-6-3-100	336	27	14	45
23. " + "	4-4-3-100	376	14	9	66
24. COC-S + "	4½-3-100	371	18	17	32
25. Zerlate + "	2-3-100	407	12	33	29
26. Fermate + "	2-3-100	424	8	28	27
27. Dithane + "	4-3-100	384	18	19	36
28. Bordeaux and DDT alternating		394	12	14	34
29. " and Bordeaux + DDT alternating		360	10	7	36
30. Zerlate and Zerlate + DDT alternating		372	17	14	39
31. No treatment		292	48	4	86

Table 15. Comparative effectiveness of calcium arsenate and DDT in the control of aphids and subsequently on foliage condition and yields of Erie potatoes grown at Wooster in 1945.

Treatments	Yield in Bu/Acre	Aphids per leaf	Percent foliage dead on Aug. 20
1. DDT only	457	60	25
2. Bordeaux + Cal. arsenate	217	870	60
3. Copper A + " "	188	930	60
4. Zerlate + " "	201	1030	52
5. Fermate + " "	180	890	62
6. Bordeaux + DDT	425	125	35
7. Copper A + "	447	40	25
8. Zerlate + "	472	220	20
9. Fermate + "	500	30	17
10. " + BHC	395	145	31
11. No treatment	381	170	32
Averages			
Fungicides + Calcium arsenate	197	930	59
Fungicides + DDT	461	103	24

Table 16. Comparative effectiveness of calcium arsenate and DDT in the control of flea beetles, leafhoppers and aphids when used with four different fungicides. Data are averages of four different experiments in 1945.

Materials	Formulas	Flea beetle punctures per leaf Avg. 4 trials	Leafhopper nymphs per 100 leaves Avg. 4 trials	Aphids per leaf Avg. 5 trials	Yields in bushels per acre Avg. 3 trials	Percent Defoliation
Calcium arsenate						
Bordeaux + Ca. arsenate	8-8-4-100	11	60	498	280	42
COC-S + " "	4½-4-100	9	53	411	277	47
Zerlate + " "	2-4-100	10	111	565	290	43
Fermate + " "	2-4-100	10	431	500	255	51
DDT						
Bordeaux + DDT	8-8-3-100	6	0	10	405	29
COC-S + "	4½-3-100	7	0	7	394	32
Zerlate + "	2-3-100	5	0	12	445	26
Fermate + "	2-3-100	7	0	9	422	31
No treatment		35	661	26	265	54
Averages						
Fungicides + Ca. arsenate		10	164	494	276	46
" + DDT		6	0	10	417	29

Table 18. The influence of various fungicides on disease control, yield, bloom, and frost sensitivity of Katahdin potatoes at Wooster in 1946.

Treatments	Formulas	Yield Bu/Acre	Percent foliage dead on Sept.28	Percent foliage alive after frost on Oct.4	Percent foliage killed by frost	Bloom when check= 100
1. No treatment		242	62	8.0	80	100
2. Bordeaux + DDT	8-8-1-100	281	30	2.5	96	161
3. COC-S + DDT	4-1-100	283	34	10.0	85	162
4. Copper hydrate + DDT	3.5-1-100	308	21	17.5	78	170
5. Copper A + DDT	4-1-100	269	31	5.0	93	183
6. Cuprocide + DDT	2-1-100	262	39	5.0	92	124
7. Tenn Zinc + DDT	2-1-100	270	30			110
8. Tribasic + DDT	4-1-100	283	24	10.0	87	153
9. Tribasic + Dresinate + DDT	4-.5-1-100	254	26	5.0	93	144
10. Phygon + DDT	1-1-100	285	22			175
11. Dithane Z-78 + DDT	2-1-100	302	22	37.5	52	204
12. Bioquin + DDT	2-1-100	289	27	35.0	52	174
13. Parzate + DDT	2-1-100	300	22	35.0	55	204
14. Zerlate + DDT	2-1-100	296	20	40.0	50	212
15. Zerlate + Parz. Alternating	14&13	303	21	40.0	49	190
16. Zerlate & COC-S + DDT	14&13	311	24	15.0	80	176
17. Zerlate & Bdx. + DDT	14 & 2	258	30	7.5	89	165
Averages of the copper sprays		281	29	7.9	89	160
Averages of the organic sprays		298	22	37.5	52	200
L. S. D. at the 5% level		31				

Table 17. Comparative effectiveness of various insecticides used with Bordeaux; of various Bordeaux formulations used with DDT; and of various fixed copper, dithiocarbamates and miscellaneous fungicides used with DDT in the control of diseases and insects of potatoes planted at Marietta, Wooster and McGuffey in 1946.

Materials	Formulas	Marietta				Wooster		
		Yield Bu/Acre	Percent foliage dead	Flea beetle punctures per leaflet	Leafhopper nymphs per 100 leaves	Yield Bu/Acre	Percent foliage dead	Flea beetle punctures per leaflet
1. No Treatment		219	82	8.5	27.4	220	72	88.0
2. Bordeaux	8-8-100	323	52	4.7	18.3	251	47	11.0
3. Bordeaux + gammexane	8-8-1-100	381	49	1.8	15.4	303	37	6.0
4. Bordeaux + Rhothane	8-8-1-100	409	43	2.0	15.3	272	37	3.0
5. Bordeaux + Methoxychlor	8-8-1-100	424	43	2.4	9.9	284	41	3.0
6. Dithane Z-78 + Rhothane	2-1-100	409	43	4.2	11.6	304	34	10.0
7. Crag 169A + DDT	5.5-1-100	493	27	1.5	4.4	381	22	0.3
8. Bordeaux + DDT	8-16-1-100	486	33	1.4	5.8	369	27	0.1
9. Bordeaux + DDT	8-8-1-100	491	32	0.7	3.6	365	29	0.8
10. Bordeaux + DDT	8.4-1-100	483	30	0.8	3.6	390	26	0.3
11. Bordeaux + DDT	6-6-1-100	494	35	0.5	4.4	385	22	0.1
12. Bordeaux + DDT	4-4-1-100	435	38	0.8	4.6	394	26	0.2
13. Bordeaux + DDT + gammexane	8-8-.5-.5-100	507	31	0.4	4.8	375	23	0.5
14. Dithane Z-78 + DDT	2-1-100	511	32	0.6	5.5	363	25	0.3
15. Dith. D-14 + $ZnSO_4$ + lime + DDT	4-1-.5-1-100	506	33	1.0	6.6	403	21	0.9
16. COC-S + DDT	4-1-100	481	35	0.4	4.2	356	28	.5
17. COC-S + bentonite + DDT	4-1-1-100	449	42	0.6	4.9	323	24	.4
18. COC-S + Bioquin + DDT	3-1-1-100	440	40	1.2	4.5	347	32	.3
19. Copper hydrate + DDT	3.5-1-100	486	41	0.5	8.5	320	27	.2
20. Tribasic + DDT	4-1-100	463	40	0.4	4.6	348	29	.4
21. Zerlate + DDT	2-1-100	498	37	0.7	3.6	414	18	.2
22. Zerl. + Parz. + DDT	1-1-1-100	488	33	1.2	4.9	425	19	.4
23. Parzate + DDT	2-1-100	483	34	0.8	4.0	403	20	.7
24. Manzate + DDT	2-1-100	466	41	0.7	3.9	379	25	.3
25. Bioquin + DDT	2-1-100	486	37	0.8	4.3	394	25	.2
26. ZnMBT + DDT	3-1-100	440	42	0.7	4.3	360	22	.4
27. Fermate + DDT	2-1-100	441	43	0.6	3.9	337	26	.5
28. Cu-Lime Dust + DDT	20-74-6	478	44	1.1	7.9	309	49	.4
29. COC-S + Talc + DDT	14-6-80	511	35	1.0	3.8	320	34	.3
30. Zerlate + Talc + DDT	10-6-84	515	33	0.4	3.8	328	27	.5

Table 17 Continued

Materials	Formulas	McGuffey: Yield Bu/Acre	McGuffey: Percent foliage dead	McGuffey: Flea beetle punctures per leaflet	Averages: Yield Bu/Acre	Averages: Percent foliage dead	Averages: Flea beetle punctures per leaflet
1. No treatment		398	90	19.0	279	81	38.5
2. Bordeaux	8-8-100	468	73	10.0	347	57	8.4
3. Bordeaux + gammexane	8-8-1-100	463	70	7.0	382	52	4.9
4. Bordeaux + Rhothane	8-8-1-100	475	67	10.0	385	49	5.0
5. Bordeaux + methoxychlor	8-8-1-100	503	67	8.0	404	50	4.3
6. Dith. Z-78 + Rhothane	2-1-100	480	61	12.0	398	46	8.7
7. Crag 169A + DDT	5.5-1-100	583	34	3.9	486	28	1.6
8. Bordeaux + DDT	8-16-1-100	573	49	3.2	476	36	1.6
9. Bordeaux + DDT	8-8-1-100	548	48	3.0	468	36	1.5
10. Bordeaux + DDT	8-4-1-100	533	54	4.4	469	37	1.8
11. Bordeaux + DDT	6-6-1-100	550	55	3.6	476	37	1.4
12. Bordeaux + DDT	4-4-1-100	530	58	2.5	453	41	1.2
13. Bordeaux + DDT + gammexane	8-8-.5-.5-100	518	59	4.0	467	38	1.6
14. Dithane Z-78 + DDT	2-1-100	543	53	4.5	472	37	1.8
15. Dith. D-14 + $ZnSO_4$ + lime + DDT	4-1-.5-1-100	585	39	2.6	498	31	1.5
16. COC-S + DDT	4-1-100	563	56	1.8	467	50	0.9
17. COC-S + bentonite + DDT	4-1-1-100	520	72	3.2	431	46	1.5
18. COC-S + Bloquin + DDT	3-1-1-100	573	54	3.5	453	42	1.7
19. Copper hydrate + DDT	3.5-1-100	513	64	2.8	440	44	1.2
20. Tribasic + DDT	4-1-100	533	62	2.6	448	44	1.1
21. Zerlate + DDT	2-1-100	540	55	5.2	484	37	2.0
22. Zerl. + Parz. + DDT	1-1-1-100	618	35	2.6	510	29	1.4
23. Parzate + DDT	2-1-100	623	42	5.9	503	32	2.4
24. Manzate + DDT	2-1-100	575	42	1.9	473	36	1.0
25. Bloquin + DDT	2-1-100	585	39	4.0	488	34	1.7
26. ZnMBT + DDT	3-1-100	568	39	3.0	456	34	1.4
27. Fermate + DDT	2-1-100	543	56	3.0	440	42	1.4
28. Cu-Lime Dust + DDT	20-74-6	533	61	3.2	440	51	1.6
29. COC-S + Talc + DDT	14-6-80	563	54	0.6	465	41	0.6
30. Zerlate + Talc + DDT	10-6-84	620	26	1.6	488	29	0.8

Table 17A. A continuation of the "Wooster" section of Table 17, listing certain treatments that were not used at Marietta or McGuffey.

Materials	Formulas	Yield in Bu/Acre	Percent of Foliage dead
1. No treatment		220	72
16. COC-S + DDT	4-1-1-100	356	28
17. COC-S + DDT	6-1-1-100	342	31
18. COC-S + bentonite + DDT	4-1-1-100	347	24
19. COC-S + Omilite + DDT	4-4-1-100	337	34
20. COC-S + Florigel + DDT	4-2-1-100	332	34
22. Tribasic + DDT	4-1-100	348	29
23. Tribasic + $ZnSO_4$ + lime + DDT	4-1-.5-1-100	367	22
27. Copper thalate + DDT	4-1-100	311	40
30. Methasan + DDT	4-1-100	381	20
38. Guantal + DDT	4-1-100	318	36
39. ZnMBT + DDT	4-1-100	360	22
40. Omilite + DDT	4-1-100	352	28
41. Zn-Fe-Mn-Cu Bis. + DDT	4.5-1-100	389	22
42. Zn-Fe-Mn-Cu. Di-M. + DDT	4.5-1-100	367	25
L.S.D. at 5% level		30	

Table 19. The effect on yield, defoliation, leafhopper populations, and flea beetle damage of spraying 10 potato varieties with COC-S + DDT at Wooster in 1946.

Varieties	Yield in Bu/Acre		Percent increase due to spraying	Percent foliage dead on August 17		Leafhopper nymphs per 100 leaves on July 15		Flea beetle holes per 1.5 cm. disc on July 15	
	Unsprayed	Sprayed		Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed
Warba	126	334	164	100	95	38	0	19	0.2
Bliss Triumph	163	406	149	100	70	68	0	17	1.5
Irish Cobbler	254	472	86	97	80	14	0	16	0.0
Katahdin	215	464	116	80	20	9	0	13	0.5
Chippewa	231	456	97	97	37	7	0	14	0.2
Pontiac	275	583	112	77	22	27	0	11	0.1
Sebago	276	513	86	45	15	5	0	8	0.3
Erie	318	590	86	70	25	1	0	10	0.3
Russet Rural	231	465	101	70	17	1	0	10	0.2
Sequoia	261	540	107	30	7	0	0	8	0.0
Averages	235	482	105	77	39	17	0	13	0.3

Table 21. The comparative performance of various fungicide-insecticide dust formulations in the control of diseases and insects on Irish Cobbler potatoes grown at Wooster in 1946. Early blight medium and late blight very scarce.

Materials	Formulas	Yield in Bu/Acre	Percent of foliage dead
1. COC-S + DDT + EM Talc	16-4-80	320	34
*2. COC-S + DDT + EM Talc	32-8-60	281	38
3. COC-S + DDT + Diluex	16-4-80	281	48
4. COC-S + DDT + Florigel + Talc	16-4-8-72	321	38
5. Tribasic + DDT + EM Talc	11-4-80	293	35
6. Copper Hydrate + DDT + EM Talc	13-4-83	300	39
7. Bioquin + DDT + EM Talc	8-4-88	316	34
8. Fermate + DDT + EM Talc	8-4-88	302	38
9. Zerlate + DDT + EM Talc	8-4-88	328	27
*10. Zerlate + DDT + EM Talc	16-8-76	345	27
11. Zerlate + DDT + Diluex + Talc	8-4-88	332	38
12. Zerlate + Manzate + DDT + Talc	4-4-4-88	316	39
13. Zerlate + BHC + DDT + Talc	8-2-2-88	311	29
14. Zerlate + Methoxy. + DDT + Talc	8-2-2-88	305	30
15. Parzate + DDT + Talc	8-4-88	343	27
16. Manzate + DDT + Talc	8-4-88	311	31
17. Ni Bis + DDT + Talc	8-4-88	306	36
18. Dithane Z-78 + DDT + Talc	10-6-84	345	27
19. Cuprocide + DDT + Talc		322	37
20. Cu-Lime + DDT	20-74-4	309	49
21. Cu-Lime + Talc + DDT	20-38-38-4	294	53
22. No Treatment		220	72
L.S.D. at 5% level		27	

*Treatments 2 and 10 applied at 25#/Acre, all others at 50#.

Table 22. Disease and insect control on potatoes at Marietta, Wooster and McGuffey by various fungicide-insecticide formulations applied as sprays and dusts in 1947.

Treatments	Formulas	Yields in Bu/Acre at*				Percent Foliage Dead at*				Flea beetles* per 10 sweeps	
		I	II	III	Ave.	I	II	III	Ave.	I	III
1. No treatment		365	354	644	454	70	83	76	76	41.0	197.6
2. DDT (50-W)	1-100	396	417	715	509	72	64	64	64	6.1	26.6
3. Bordeaux	8-8-100	415	407	778	533	51	46	62	53	13.5	63.6
4. Bordeaux + DDT 50-W	8-8-1-100	491	445	815	584	45	34	59	46	4.8	19.0
5. Bordeaux + DDTol (25%)	8-8-2-100	478	437	814	576	39	35	53	42	3.9	16.0
6. COC-S + Deenal	4-2-100	429	431	810	557	48	44	65	52	6.8	16.6
7. COC-S + DDT	4-1-100	466	438	777	560	40	48	64	51	1.5	22.3
8. COC-S + Dowklor (50%)	4-1-100	461	415	783	553	40	51	65	52	9.2	47.6
9. COC-S + toxaphene (25%)	4-3-100	473	440	736	550	40	53	59	51	6.5	20.0
10. COC-S + heptachlor	4-2-100	351	414	754	507	67	53	61	60	13.4	61.0
11. Tribasic + DDT	4-1-100	496	494	789	593	38	39	63	47	3.9	41.6
12. Tribasic + Tenn Zinc + DDT	4-1-1-100	531	469	798	599	32	37	51	40	1.7	11.3
13. Tribasic + $ZnSO_4$ + lime + DDT	4-1-.5-1-100	517	455	801	591	34	37	51	41	3.9	21.3
14. D-14 + $ZnSO_4$ + lime + DDT	4-1-.5-1-100	540	473	854	622	33	35	50	39	5.6	12.6
15. Zerlate + DDT	2-1-100	545	453	806	601	30	38	49	39	2.7	25.6
16. Parzate + DDT	2-1-100	502	453	856	604	34	33	41	41	1.8	37.3
17. Zerlate + Parzate + DDT	1-1-1-100	506	528	837	624	38	33	44	38	2.1	28.0
18. Zerlate + Ortho-K + DDT	2-2-1-100	521	472	812	602	32	30	46	36	8.3	35.3
19. Zerlate + COC-S + DDT	1-2-1-100	522	500	848	623	31	33	47	37	5.9	7.0
20. Zerlate & COC-S alternating		555	521	843	640	35	36	49	40	3.5	25.0
21. Zerlate & Parzate alternating		566	550	844	653	35	27	39	34	3.1	4.6
22. Methasan (N-1286) + DDT	1.5-1-100	522	430	768	573	42	60	54	52	3.9	24.0
23. Phygon + DDT	1-1-100	460	470	790	573	49	51	54	51	5.2	12.0
24. Bioquin (50) + DDT	1-1-100	545	430	767	581	42	43	59	48	5.6	35.0
25. Copper-zinc-chromate + DDT	4-1-100	586	518	806	637	24	28	38	30	4.6	9.0
Dusts											
26. COC-S + DDT + Talc	13-6-81	588	458	740	595	30	47	57	45	1.5	22.3
27. Zerlate + DDT + Talc	10-6-84	706	509	765	660	21	31	47	33	1.1	29.6
28. Dithane Z-78 + DDT + Talc	10-6-84	690	428	779	632	26	50	56	44	1.3	33.6
29. Zerlate + Parzate + DDT + Talc	5-5-6-84	679	497	772	649	25	35	41	34	1.3	34.3
30. Zerlate + COC-S + DDT + Talc	5-7-6-82	666	437	824	642	24	50	48	41	2.1	42.3
L.S.D. at 5% level		52	50	73							

*I Marietta, II Wooster, III McGuffey.

Table 23. Comparative disease control on Cobbler potatoes by a series of copper-zinc-chromate formulations and several formulated organic compounds at Wooster in 1947. Both early and late blight present.

Treatments*	Formulas	Yield in Bu./Acre	Percent foliage dead	Late Blight in Plots Checked
1. Crag 658	1-1-100	395	34	
2. Crag 658	2-1-100	429	32	
3. Crag 658	3-1-100	413	33	
4. Crag 658 + Tribasic	1-2-1-100	428	36	
5. Crag 658 + Phygon	1-.5-1-100	403	34	
6. Crag 640	2-1-100	386	34	
7. Crag 169	2-1-100	426	27	
8. Crag 679	3-1-100	413	47	
9. Crag 639C	2-1-100	396	45	x
10. Crag 585	3-1-100	380	48	
11. Chromate complex (698)	4-1-100	414	32	
12. Bioquin I	1-1-100	375	41	
13. Bioquin 100	1-1-100	381	53	
14. Bioquin I + 100	.5-.5-1-100	438	45	x
15. Copper phthalate	2-1-100	375	60	
16. Zinc phthalate	2-1-100	368	54	
17. Phthalate complex**	4-1-100	315	68	
18. ZnMBT	3-1-100	373	45	x
19. CuMBT	3-1-100	368	50	
20. N-1286	2-1-100	373	60	
21. N-3511	2-1-100	410	46	x
22. N-2230	2-1-100	400	38	x
23. Zac	2-1-100	458	28	
24. COC-S	4-1-100	412	39	
25. DDT only	1-100	324	65	
26. No treatment		300	83	x
L.S.D. at 5% level		50		

*All treatments combined with DDT

**Phthalate complex consisted of a mixture of Zn, Cu, Fe and Mn phthalates.

N-1286 = Zinc ethylene bix (N-2 cyanoethyl) dithiocarbamate

N-3511 = Zinc N-ethyl (N-beta-cyanoethyl) dithiocarbamate

N-2230 = Di-cyclopenta-ethylene dithiocarbamate

Zac = Zinc dimethyl dithiocarbamate - cyclohexylamine

Table 20. The effect on yield of spraying 10 varieties of potatoes with COC-S + DDT at McGuffey in 1946.

Varieties	Yield in bushels per acre		Increase due to spraying	
	Unsprayed	Sprayed	Bushels Per Acre	Percent
Warba	387	599	212	55
Bliss Triumph	436	643	207	47
Cobbler	490	610	120	25
Katahdin	436	588	152	35
Chippewa	512	664	152	30
Pontiac	517	740	223	43
Sebago	354	495	141	40
Erie	479	664	185	39
Russet Rural	310	539	229	95
Sequoia	425	545	120	28
Averages	430	640	180	42

Table 24. Comparative disease control on Katahdin potatoes by a series of copper-zinc-chromate formulations at Wooster in 1947. Both early and late blights present.

Treatments* *	Formulas	Yields in Bu./Acre	Percent Foliage Dead Sept.21
1. Crag 658	1-1-100	395	51
2. Crag 658	2-1-100	392	39
3. Crag 658	3-1-100	401	37
4. Crag 658 + Tribasic	1-2-1-100	362	42
5. Crag 658 + Phygon	1-.5-1-100	411	42
6. Crag 640	2-1-100	385	37
7. Crag 169	2-1-100	388	45
8. Crag 679	3-1-100	396	51
9. Crag 639C	2-1-100	365	54
10. Crag 585	3-1-100	375	52
11. Chromate complex (698)	4-1-100	412	36
12. N-1286*	2-1-100	327	61
13. N-3511*	2-1-100	367	57
14. N-2230*	2-1-100	366	60
15. Zac	2-1-100	426	50
16. No treatment		288	88
L.S.D. at 5% level		35	

**All treatments combined with DDT

*See Table 23

Table 25. The influence of various oil and diluent additives on the fungicidal efficacy of COC-S dust formulations in the control of potato diseases at Wooster in 1947. Several fungicides are also compared in spray applications.

Treatments	Formulas	Yield in Bu./Acre	Percent foliage dead on Sept.20
Dusts			
1. COC-S + Corvus oil + Diluex + EM Talc	14-3-15-68	291	76
2. " + Corvus " + " + "	14-5-15-66	289	68
3. " + Corvus " + " + "	14-8-15-63	246	67
4. " + S.E.C. " + " + "	14-5-15-66	293	66
5. " + Vaporal " + " + "	14-5-15-66	298	69
6. " + Sun Vis " + " + "	14-5-15-66	289	74
7. " + Water + " + "	14-5-15-66	286	75
8. " + Diluex + "	14-15-71	284	67
9. " + Celite + "	14-15-71	315	67
10. " + Talc only	14-86	300	64
Sprays			
11. COC-S + FB 218 + DDT	4-1-1-100	335	45
12. COC-S + p.e.p.s. + DDT	4-1-1-100	333	45
13. COC-S + ZI + DDT	4-1-1-100	304	51
14. Bordeaux + DDT	8-8-1-100	324	32
15. Dithane Z-78 + DDT	2-1-100	331	47
16. Zerlate + DDT	2-1-100	306	57
17. Phygon + DDT	1-1-100	288	52
18. COC-S + DDT	4-1-100	314	45
19. Parzate + DDT	2-1-100	340	42
20. No treatment		263	90
L.S.D. at 5% level		27	

Table 26. Comparative disease control on potatoes at Wooster in 1947 by several good fungicides (First section of table), comparative effect of fungicides and DDT on disease control and yield (Second section), and disease control when fungicides were applied with a steam jenny (Third section).

		Station Farm		Snyder Farm	
Treatments*	Formulas	Yield in Bu./Acre	Percent foliage dead	Yield in Bu./Acre	Percent foliage dead
1. COC-S	4-1-100	314	45	415	45
2. Zerlate	2-1-100	306	57	402	49
3. Dithane Z-78	2-1-100	311	47	393	49
4. Phygon	1-1-100	288	52	398	42
5. Parzate	2-1-100	340	42	419	32
6. Bordeaux	8-8-1-100	324	32	440	49
7. No treatment		263	90	288	82

*All treatments combined with DDT

		Cobblers with early blight		Katahdins with late blight	
Treatments*	Formulas	Yield in Bu./Acre	Percent foliage dead	Yield in Bu./Acre	Percent foliage dead
1. COC-S	4-1-100	412	39	418	48
2. Crag 658	2-1-100	426	27	388	45
3. Zac	2-1-100	458	28	426	50
4. DDT only	1-100	324	65	286	69

*All treatments combined with DDT

Treatments		Formulas	Yield in Bu./Acre	Percent foliage dead
1. COC-S	(open boom)	2# in 4 gal. water	326	60
2. COC-S	(open boom)	"	311	72
3. Zerlate	(open boom)	1# in 4 gal. water	328	77
4. Dithane Z-78	(open boom)	"	322	72
5. No treatment			288	82

Table 27. Data on yield and foliage condition when potatoes were sprayed with various insecticides and fungicides at Marietta, Wooster and Sandusky during the summer of 1948.

Treatments	Formulas	Yields in Bu/Acre at				Percent foliage dead at			
		Marietta	Wooster	Sandusky	Ave.*	Marietta	Wooster	Sandusky	Ave.
1. No treatment		398	408	495	403	79	86	73	79
2. Procap + DDT	4-1-100	515	539	530	527	32	44	51	42
3. COC-S + DDT	4-1-100	538	490	561	514	40	52	49	47
4. COC-S + Toxaphene	4-3-100	527	477	499	502	39	47	61	49
5. COC-S + Dowchlor	4-1-100	519	533	522	526	43	40	55	46
6. COC-S + Isotox	4-.5-100	524	517	542	521	46	42	49	46
7. COC-S + TEPP	4-.25-100	466	526	555	516	40	44	47	44
8. COC-S + parathion	4-1-100	519	565	546	542	42	39	43	41
9. Tribasic + DDT	4-1-100	557	527	613	542	28	36	46	37
10. Tribasic A + DDT	5-1-100	558	560	572	559	25	30	34	30
11. Bordeaux + DDT	8-4-1-100	562	533	568	548	27	46	46	40
12. L658 + DDT	2-1-100	545	598	523	572	38	29	34	34
13. L640 + DDT	1.5-1-100	555	555	515	555	38	32	37	36
14. CIMBT + DDT	3-1-100	536	470	562	503	44	80	56	60
15. Zn CIMBT + DDT	3-1-100	489	534	559	512	50	49	50	50
16. Methasan B + DDT	3-1-100	536	547	572	542	52	35	37	41
17. N-2230 + DDT	3-1-100	489	531	573	510	56	55	44	52
18. Zn-MBT + DDT	3-1-100	519	506	584	513	53	74	51	59
19. Zac + DDT	2-1-100	508	528	560	518	57	39	34	43
20. F629 + FE + DDT	3-1-1-100	489	523	566	506	55	48	45	49
21. F629 + 308 + FF + DDT	3-1-1-100	510	563	584	537	50	35	40	42
22. Dithane D-14 + $ZnSO_4$ + DDT	4-1-1-100	599	603	592	601	34	32	29	32
23. Dithane Z-78 + DDT	2-1-100	587	603	575	590	25	31	30	29
24. Parzate + DDT	2-1-100	606	620	526	613	33	30	38	34
25. Zerlate + DDT	2-1-100	569	566	563	568	44	31	34	36
26. Zerlate + Parzate + DDT	1-1-1-100	580	614	595	597	41	31	35	36
27. Zerlate + COC-S + DDT	1-2-1-100	548	568	527	558	33	36	40	36
28. Zerlate + spray adhesive + DDT	2-1-1-100	527	579	631	553	43	35	32	37
29. Zerlate & Parzate alternating		594	590	561	592	36	30	38	35
30. Zerlate & COC-S alternating		566	530	560	548	41	35	46	41
L.S.D. at 5% level		44	53	65		8	7	9	

*Yield averages are for Marietta and Wooster only.

Table 28. The comparative performance, in terms of yield and control of defoliation, of a series of new fungicide-containing formulations on early-planted Irish Cobblers at Wooster in 1948.

Treatments*	Formulas	Yields in Bu./Acre	Percent Foliage Dead on Aug. 6
1. Ca carbamate + $ZnSO_4$	4-1-1-100	537	25
2. Na " + "	4-1-1-100	552	32
3. Mg " + "	4-1-1-100	546	32
4. Procop 2B	4-1-100	495	34
5. Procop 3A	3-1-100	492	40
6. Procop 3B	3-1-100	474	42
7. Bioquin 50W	1-1-100	516	45
8. Bioquin 50W + Sulfur	0.5-3-1-100	462	59
9. Methasan W	1.5-1-1-100	555	30
10. Methasan S	3-1-100	573	30
11. Zac + p.e.p.s.	2-1-1-100	537	29
12. Zac S	2-1-100	498	47
13. Mn EDB	2-1-100	531	36
14. Fe (3) Cl MBT	3-1-100	495	65
15. Fe (2) Cl MBT	3-1-100	462	69
16. No treatment		408	86
L.S.D. at 5% level		50	8

*All treatments combined with DDT

Table 29. The comparative efficacy of several old and new fungicides in the control of foliage diseases on Katahdin potatoes grown at Wooster in 1948

Treatments*	Formulas	Yield in Bu./Acre	Percent foliage dead on Sept. 18
1. Ca carbamate + $ZnSO_4$	4-1-100	336	30
2. Mg " + "	4-1-100	339	27
3. Parzate	2-100	367	27
4. Zerlate	2-100	347	25
5. Dithane Z-78	2-100	356	25
6. Zac	2-100	358	30
7. Procap 2A	4-100	339	35
8. Procap 3A	3-100	319	50
9. Ni Cl MBT	3-100	356	42
10. Fe (3) Cl MBT	3-100	347	43
11. Fe (2) Cl MBT	3-100	319	70
12. L658	2-100	342	25
13. F629	3-100	336	52
14. COC-S	4-100	328	37
15. Tribasic	4-100	312	40
16. Tribasic A	5-100	342	37
17. Bioquin 50W	1-100	339	40
18. No treatment		294	75
L.S.D. at 5% level		25	8

*DDT (50% W.P.) used with all fungicides at 1-100.

Table 30. The influence of various adjuvants on the performance of dust formulations prepared with Tribasic and with copper-Zinc-chromate (L658) when applied to Irish Cobblers at Wooster in 1948.

Treatments	Formulas	Yield in Bu./Acre	Percent Foliage Dead on Aug. 6	Percent Adhesion Of Copper After 10 days
1. Tribasic + EM Talc + DDT	10-84-6	481	50	16.9
2. " + AS50 + EM Talc + DDT	10-4-80-6	520	46	18.0
3. " + " + " + "	10-2-80-6	479	47	15.4
4. " + AS50R + " + "	10-4-80-6	481	45	16.5
5. " + Celite + " + "	10-15-69-6	454	60	13.3
6. " + " + " + "	10-10-74-6	490	51	14.4
7. " + " + " + "	10-5-79-6	490	50	13.5
8. " + " + Ac-DDT	10-84-6	481	45	15.6
9. " + Attaclay + "	10-43.6-6	487	49	17.2
10. " + Spec. Attaclay + "	10-20.2-6	476	55	15.4
11. L658 + EM Talc + DDT	6-88-6	506	40	16.8
12. " + " + "	10-84-6	500	35	18.3
13. " + Celite + EM Talc + DDT	6-10-78-6	490	45	12.4
14. " + Diluex + " + "	6-10-78-6	484	41	16.2
15. " + " + " + "	6-20-68-6	503	50	11.1
16. " + " + " + "	6-30-58-6	474	60	12.6
17. " + AS50 + " + "	6-4-84-6	492	42	14.7
18. Zerlate + " + "	6-86-6	536	31	
19. " + L658 + " + "	4-3-87-6	528	32	
20. " + Diluex + " + "	8-20-66-6	465	50	
21. No. 11 and No. 18 alternating		498	42	
22. No treatment		422	86	
L.S.D. at 5% level		59	9	

Table 31. The influence of adjuvants in dust formulations prepared with Tribasic and L658 as fungicides on disease control and yield of Katahdin potatoes at Wooster in 1948.

Treatments	Formulas	Yield in Bu./Acre	Percent Foliage Dead on Sept. 18
1. Tribasic + EM Talc + AC-DDT	10-84-6	329	38
2. " + EM Talc + G-DDT	10-84-6	318	40
3. " + AS50 + EM Talc + DDT	10-4-80-6	343	36
4. " + " + " + "	10-2-80-6	318	39
5. " + AS50R + " + "	10-4-80-6	307	40
6. " + Celite + " + "	10-15-69-6	318	43
7. " + " + " + "	10-10-74-6	343	39
8. " + " + " + "	10-5-79-6	340	37
9. " + Attaclay + EM Talc + AC-DDT	10-20.2-6	318	40
10. " + Spec. Attaclay + EM Talc + AC-DDT	10-43.6-6	313	42
11. L658 + EM Talc + DDT	6-88-6	329	36
12. " + " + "	10-84-6	340	33
13. " + Celite + EM Talc + DDT	6-10-78-6	318	39
14. " + Diluex + " + "	6-10-78-6	326	37
15. " + " + " + "	6-20-68-6	332	40
16. " + AS50 + " + "	6-4-84-6	326	40
17. " + Zerlate + " + "	3-4-87-6	364	30
18. Zerlate + " + "	8-86-6	345	28
19. No treatment		286	58
L.S.D. at 5% level		40	8

Table 32. Yield and foliage condition of Irish Cobblers grown at three locations in Ohio in 1949 when sprayed with various insecticide-fungicide combinations

Treatments	Formulas	Yields in Bu/Acre at: Marietta	Wooster	Willard	Ave.	Percent foliage dead at: Marietta July 27	Wooster Aug. 14	Willard Sept. 15	Ave.
1. No treatment		382	383	517	427	85	90	80	85
2. Tribasic + DDT	4-1-100	430	490	584	501	72	56	27	52
3. Tribasic + parathion	4-1-100	443	470	633	515	45	46	35	42
4. Tribasic + EPN	4-.7-100	488	473	616	526	55	58	32	48
5. Tribasic + Marlate	4-2-100	427	453	614	498	54	69	37	53
6. Tribasic + CS645	4-1-100	472	487	600	520	62	59	32	51
7. Tribasic + Comp. 118	4-1-100	499	503	569	524	40	44	37	40
8. Tribasic + p.e.p.s. + DDT	4-.5-1-100	477	493	573	514	41	41	27	36
9. Cop-O-Zinc + DDT	4-1-100	462	497	573	511	44	45	22	37
10. COC-S + DDT	4-1-100	445	480	586	504	52	48	30	43
11. Sporcop + DDT	4-1-100	402	473	592	489	76	78	30	61
12. Fac-S + DDT	2-1-100	425	447	535	469	76	75	40	64
13. Zac-S + DDT	2-1-100	480	503	605	529	66	46	32	48
14. Zip + DDT	2-1-100	475	458	620	518	60	58	27	48
15. Crag 658 + DDT	2-1-100	472	460	570	501	61	50	20	44
16. 658Bg5 + DDT	2-1-100	474	456	610	513	55	38	22	38
17. L. Parzate + $ZnSO_4$ + DDT	4-1-1-100	475	497	642	538	32	46	20	33
18. Dithane D-14 + $ZnSO_4$ + DDT	4-1-1-100	496	490	674	553	29	49	17	32
19. Dithane Z-78 + DDT	2-1-100	548	500	642	533	42	39	20	34
20. Dithane Z-78 + Bonded + DDT	3-1-100	471	497	617	528	52	45	20	39
21. Zerlate + DDT	2-1-100	474	483	621	526	58	53	32	48
22. Zerlate + F529 + DDT	2-.1-1-100	473	473	613	520	68	59	40	56
23. Zerlate + p.e.p.s. + DDT	2-.5-1-100	490	470	620	527	49	43	27	38
24. Zerlate + VL-600 + DDT	2-1-1-100	484	477	571	511	60	50	27	46
25. Methasan S + DDT	3-1-100	507	467	589	521	46	58	25	43
26. Methasan B + DDT	3-1-100	497	477	636	537	35	51	30	39
27. Robertson Fungicide + DDT	2.2-1-100	498	467	577	514	56	50	32	46
28. EM25-3 + DDT	2-100	460	470	613	514	70	61	47	59
29. Parzate + DDT	2-1-100	495	507	675	559	33	40	22	32
30. Robt. Fung. Bonded + DDT	4-1-100	450	467	584	502	48	58	37	48
L.S.D. at 5% level		44	40	56					

Table 33. Comparative yield and foliage condition when Cobbler potatoes were sprayed with various copper-zinc-chromate formulations and various fungicides used with and without p.e.p.s. and VL-600 at Wooster in 1949.

Treatments*	Formulas	Yield in Bu./Acre	Percent Foliage Dead on Aug. 6
1. Crag 658	2-1-100	434	46
2. 658B5G	2-1-100	444	47
3. 658B2G	2-1-100	413	52
4. 658B3G	2-1-100	410	50
5. 658CG	2-1-100	443	48
6. 658B5K4G	2-1-100	390	45
7. 829B5G	2-1-100	393	47
8. 829B5K4G	2-1-100	404	44
9. 5379	2-1-100	416	49
10. Zerlate	1.5-1-100	400	51
11. Fermate	1.5-1-100	417	50
12. Parzate	1.5-1-100	446	40
13. COC-S	4-1-100	378	57
14. Zerlate + p.e.p.s.	1.5-.5-1-100	415	47
15. Zerlate + VL-600	1.5-1-1-100	412	46
16. COC-S + p.e.p.s.	4-.5-1-100	399	47
17. COC-S + VL-600	4-1-1-100	411	57
18. Zac	1.5-1-100	429	46
19. Zac + p.e.p.s.	1.5-.5-1-100	422	41
20. Zac + VL-600	1.5-.5-1-100	396	45
21. Zac S (30%)	3.4-1-100	411	45
22. Zac S	3.4-.5-1-100	444	43
23. Zac S	3.4-1-1-100	419	46
24. Zip (80-20)	3.3-1-100	399	46
25. Zip (90-10)	3.2-1-100	406	49
26. Fac S (20%)	5.5-1-100	397	56
27. Fac S + p.e.p.s.	5.5-1-1-100	404	59
28. Fac S + VL-600	5.5-1-1-100	382	63
29. Fermate + VL-600	1.5-1-1-100	370	53
30. No treatment		330	78
L.S.D. at 5% level		45	

*DDT 50W used in all formulation at 1-100.

Table 34. Efficacy of various new fungicides and formulations of the same in the control of early blight on Cobbler potatoes at Wooster in 1949.

Treatments	Formulas	Yield in Bu./Acre	Percent Foliage Dead. Ave. of July 30 & Aug. 7
1. Tribasic + DDT	4-1-100	480	48
2. " + "	2-1-100	456	48
3. " + Florigel + DDT	4-3-100	472	46
4. " + " + "	2-3-100	458	51
5. " + AS50 + "	2-2-100	498	48
6. " + VL-600 + "	2-1-100	467	51
7. CP1661 + DDT	1.5-1-100	493	54
8. Esminel N + DDT	4-1-100	476	47
9. Zerlate + DDT	2-1-100	493	45
10. " + "	1-1-100	496	52
11. " + Florigel + DDT	2-3-100	509	44
12. " + " + "	1-3-100	510	46
13. " + F529 + "	2-.1-100	493	46
14. " + " + "	1-.1-100	487	49
15. CP2271 + DDT	2-1-100	490	52
16. Mn EDB + DDT	2-1-100	523	44
17. Parzate + Mn EDB + DDT	1-.75-1-100	534	38
18. Parzate + DDT	2-1-100	531	36
19. Ca EDB + "	2-1-100	501	51
20. Crag 658 + "	2-1-100	473	51
21. Chromate A + DDT	2-1-100	476	47
22. " B + "	2-1-100	478	48
23. Penn C + DDT	3.1-1-100	490	51
24. Penn D + Talc + DDT	25-6-69	470	49
25. EM25-3	2-100	473	49
26. Fungicide B	5-100	500	41
27. " C + EM25-3	5-2-100	509	40
28. " D + "	6-1-100	532	43
29. Phelps-Dodge Copper Paste + DDT	4-1-100	515	47
30. No treatment		414	60
L.S.D. at 5% level		48	

Table 35. Comparative performance of various fungicide-insecticide formulations in disease control on Katahdin potatoes grown at Wooster in 1949.

Treatments	Formulas	Yield in Bu./Acre	Percent Foliage Dead on Oct. 3
1. No treatment		408	89
2. DDT only	1-100	468	62
3. Tribasic + DDT	4-1-100	504	39
4. Cop-O-Zinc + DDT	4-1-100	540	36
5. Robertson Fungicide + DDT	2.2-1-100	504	41
6. COC-S + DDT	4-1-100	495	41
7. " + AS50 + DDT	4-2-1-100	492	39
8. " + Florigel + DDT	4-4-1-100	495	37
9. " + p.e.p.s. + "	4-.5-1-100	528	30
10. " + VL-600 + "	4-1-1-100	525	34
11. Crag 658 + DDT	2-1-100	543	31
12. 65885g + "	2-1-100	522	32
13. 829 + DDT	2-1-100	543	30
14. 5379 + DDT	2-1-100	543	29
15. Zac S + DDT	3.4-1-100	540	32
16. Fac S + DDT	3.5-1-100	501	46
17. Zerlate + DDT	2-1-100	513	49
18. " + "	1-1-100	504	60
19. " + F529 + DDT	1-.1-1-100	522	50
20. Methasan + DDT	1.5-1-100	552	39
21. Methasan S + DDT	3-1-100	534	37
22. Methasan Bonded + DDT	3-1-100	528	37
23. D-14 + $ZnSO_4$ + DDT	4-1-1-100	573	26
24. Dithane Z-78 + "	2-1-100	594	22
25. " Bonded + DDT	3-1-100	570	25
26. L. Parzate + $ZnSO_4$ + DDT	4-1-1-100	579	26
27. Parzate + DDT	2-1-100	576	26
28. CP2271 + DDT	2-1-100	504	41
29. EM25-3	2-100	510	55
30. Fungicide B + DDT	5-1-100	555	29
31. 4502	8-100	534	39
32. 4501	8-100	492	64
33. 4500	8-100	561	45
34. Chromate A + DDT	2-1-100	528	27
35. Penn 492 + DDT	3.1-1-100	507	61
36. Zac A + DDT	2-1-100	516	37
37. Zac B + "	1.5-1-100	519	42
L.S.D. at 5% level		44	

Table 36. Effect on yield of Katahdin potatoes when p.e.p.s. was added to various fungicides used at less than the usual recommendation.

Treatments	Formulas	Yields in Bu./Acre
1. Parzate + DDT	1.5-1-100	260
2. Parzate + p.e.p.s. + DDT	1.5-.5-1-100	300
3. Methasan S + DDT	2-1-100	263
4. Methasan S + p.e.p.s. + DDT	2-.5-1-100	265
5. Mn EDB + DDT	1.5-1-100	245
6. Mn EDB + p.e.p.s. + DDT	1.5-.5-1-100	275
7. Tribasic + DDT	3-1-100	250
8. Tribasic + p.e.p.s. + DDT	3-.5-1-100	273
9. No treatment		193
Averages		
Without p.e.p.s.		255
With p.e.p.s.		278

Table 37. Influence of various insecticide-fungicide formulations on yield and defoliation of late-planted Cobbler potatoes at Willard, Ohio.

Treatments	Formulas	Yields in Bu./Acre	Percent of Foliage Dead on Sept. 28
1. D-14 + $ZnSO_4$ + DDT	4-1-1-100	669	47
2. " + " + parathion	4-1-1-100	707	39
3. " + " + EPN	4-1-.7-100	666	52
4. " + " + CS645	4-1-1-100	680	46
5. Parzate + DDT	2-1-100	685	45
6. Zerlate + "	2-1-100	582	69
7. " + VL-600 + DDT	2-1-1-100	568	70
8. COC-S + DDT	4-1-100	574	59
9. Cop-O-Zinc + DDT	4-1-100	598	61
10. Tribasic + DDT	4-1-100	566	71
11. Methasan S + DDT	3-1-100	568	57
12. " + Bonded + DDT	3-1-1-100	566	55
13. Crag 658 + DDT	2-1-100	587	56
14. Dithane Z-78 + DDT	2-1-100	604	51
15. Zac S + DDT	2-1-100	587	70
16. No treatment		538	90
L.S.D. at 5% level		70	

Table 38. Comparative performance of regular (160 g.p.a. of "X" concentrate) and 4X (40 g.p.a. of "4X" concentrate) applications of various fungicides in the control of early blight on Cobbler potatoes at Wooster in 1941.

Treatments	Formulas	Yields in Bu./Acre	Percent Foliage Dead on Aug. 17
1. COC-S + DDT	16-4-100	494	56
2. COC-S + DDT	4-1-100	478	50
3. Methasan S + DDT	12-4-100	494	36
4. Methasan S + DDT	3-1-100	484	34
5. L. Parzate + $ZnSO_4$ + DDT	16-4-4-100	523	34
6. L. Parzate + $ZnSO_4$ + DDT	4-1-1-100	528	24
7. Dithane Z-78 + DDT	8-4-100	473	61
8. Dithane Z-78 + DDT	4-1-100	536	27
9. Zac S	8-4-100	485	69
10. Zac S	4-1-100	491	45
11. No treatment		407	94
L.S.D. at 5% level		44	
Averages			
4X formulations (5)		494	51
X formulations (5)		503	36

Table 41. Yield and foliage condition of potatoes at Wooster in 1950 when sprayed with a number of new fungicidal formulations. Only early blight present on foliage.

Treatments	Formulas	Yields in Bu./Acre	Percent Foliage Dead on Aug. 2
1. No treatment		377	83
2. CP 2271 + DDT	2-1-100	434	49
3. CP 1161 + DDT	2-1-100	407	46
4. P-D Paste + DDT	4-1-100	418	44
5. C 5400 + DDT	2-1-100	430	35
6. Methasan W + DDT	1-.5-1-100	434	35
7. Methasan S + DDT	3-1-100	454	30
8. Methasan B + DDT	3-1-100	427	32
9. Orthocide 406 + DDT	2-1-100	392	40
10. Copper cupferron + DDT	4-1-100	423	37
11. Cu-Zn cupferron + DDT	4-1-100	399	37
12. MnEDB + DDT	1.7-1-100	427	34
13. Parzate + DDT	2-1-100	472	24
14. Bordeaux + DDT	8-8-1-100	407	43
15. Vancide 51 + DDT	3-1-100	404	40
16. Vancide 20S + DDT	2-1-100	418	57
17. Vancide 29EC + DDT	2-1-100	405	62
18. Zac X6 + DDT	6-1-100	406	42
19. Zac X6 + p.e.p.s. + DDT	6-.5-1-100	435	37
20. Fungicide B + DDT	5-1-100	437	31
21. F 1124 + DDT	5-1-100	399	39
22. F 1189 + DDT	5-1-100	430	37
23. Fungicide A + DDT	5-1-100	410	39
24. Fungicide C + DDT	4-1-100	396	40
L.S.D. at 5% level		50	

Table 39. Potato yields and foliage condition at Marietta, Wooster and Willard in 1950 when sprayed with the same formulations at all three locations. Early blight only was present at Wooster and Willard. Both early and late blight occurred at Marietta.

Treatments	Formulas	Yields in Bu/Acre at				Percent foliage dead at			
		Marietta	Wooster	Willard	Ave.	Marietta	Wooster	Willard	Ave.
1. No treatment		332	300	600	411	55	91	90	79
2. Tribasic + DDT	4-1-100	390	346	652	463	22	56	62	47
3. Tribasic + parathion	4-1-100	410	348	678	479	20	63	47	43
4. Tribasic + aldrin	4-1-100	392	345	629	455	24	47	57	43
5. Tribasic + dilan	4-1-100	437	355	665	486	17	50	55	41
6. Tribasic + EPN	4-1-100	416	334	643	464	17	51	62	43
7. Tribasic + aldrin + DDT	4-.7-.7-100	389	344	630	454	24	59	60	48
8. Tribasic + DDT	3-1-100	387	335	628	450	22	50	62	45
9. Tribasic + DDT + p.e.p.s.	4-1-.5-100	455	350	671	492	15	51	50	39
10. Cop-O-Zinc + DDT	4-1-100	431	351	646	476	20	42	47	36
11. COC-S + DDT	4-1-100	412	369	642	474	20	56	52	43
12. Robertson Copper + DDT	2.2-1-100	383	359	669	470	28	51	52	44
13. Copper cupferron + DDT	3-1-100	393	386	674	484	31	45	45	40
14. CP2271 + DDT	3-1-100	372	373	660	468	45	52	67	55
15. Crag 658 + DDT	2-1-100	413	374	649	479	30	46	47	41
16. Methasan S + DDT	3-1-100	382	380	701	488	22	38	27	29
17. Methasan B + DDT	3-1-100	378	377	693	483	28	44	35	36
18. Zerlate + DDT	2-1-100	395	381	674	483	28	37	55	40
19. Zac-X6 + DDT	6-1-100	368	365	644	459	38	45	52	46
20. Zac-X6 + p.e.p.s. + DDT	6-.5-1-100	384	381	654	470	35	42	52	43
21. D-14 + $ZnSO_4$ + DDT	4-1-1-100	464	382	688	511	9	37	25	29
22. Z-78 + DDT	2-1-100	455	376	708	511	12	44	32	29
23. Z-78 + p.e.p.s. + DDT	2-.5-1-100	445	382	673	500	13	38	37	29
24. Fungicide 1189 + DDT	5-1-100	449	348	645	481	13	49	65	42
L.S.D. at 5% level.		48	51	47					

Table 40. Yield and foliage condition of Katahdin potatoes when sprayed in 1950 at Wooster with various fungicides and formulations of the same. Both early and late blight were present.

Treatments	Formulas	Yields in Bu./Acre	Percent Foliage Dead on Sept.10
1. No treatment		428	80
2. COC-S + DDT	4-1-100	520	36
3. COC-S + parathion	4-1-100	546	25
4. COC-S + Dilan	4-1-100	530	26
5. COC-S + p.e.p.s. + DDT	4-.5-100	541	25
6. Tribasic + DDT	4-1-100	523	25
7. Cop-O-Zinc + DDT	4-1-100	569	26
8. Robertson copper + DDT	2.2-1-100	528	29
9. P-D Paste + DDT	4-1-100	515	30
10. Crag 658 + DDT	2-1-100	522	26
11. Copper cupferron + DDT	3-1-100	526	25
12. CP 1661 + DDT	3-1-100	507	41
13. CP 2271 + DDT	3-1-100	493	44
14. F 1124 + DDT	5-1-100	470	41
15. F 1189 + DDT	5-1-100	480	32
16. Vancide 51 + DDT	3-1-100	463	32
17. Methasan S + DDT	3-1-100	557	26
18. Zac S + DDT	3-1-100	531	34
19. Zerlate + DDT	2-1-100	493	35
20. D-14 + $ZnSO_4$ + DDT	4-1-1-100	584	15
21. Parzate + DDT	2-1-100	557	15
22. MnEDB + Triton 1956 + DDT	1.7-.2-1-100	569	15
23. C 5400 + DDT	2-1-100	526	29
24. Orthocide 406 + DDT	2-1-100	488	31
25. Tribasic + DDT	3-1-100	451	45
26. Zerlate + Tribasic + DDT	1-2-1-100	466	39
27. Robertson copper + p.e.p.s. + DDT	2.2-.5-1-100	482	32
28. Fungicide A + DDT	5-1-100	475	39
29. Fungicide B + DDT	5-1-100	473	36
30. Fungicide C + DDT	4-1-100	495	35
31. Vancide 20S + DDT	3-1-100	467	61
32. Vancide 293C + DDT	3-1-100	457	65
33. Methasan W + DDT	1-.5-1-100	497	37
34. Methasan B + DDT	1-.5-1-100	482	47
35. Methasan B + DDT	.75-1-100	445	64
36. Zac X5 + DDT	6-1-100	471	54
37. Zac X6 + DDT	6-1-100	482	65
38. Zac X6 + p.e.p.s. + DDT	6-.5-1-100	456	65
39. Zac X6 + Latex + DDT	6-1-1-100	456	65
40. 49-CS-43 + DDT	3-1-100	424	80
41. Bordeaux + DDT	8-6-1-100	473	29
L.S.D. at 5% level		32	

Table 42. Yield and foliage condition of potatoes sprayed at Wooster in 1950 with various fungicides differently formulated. Early blight only foliage disease present

Treatments	Formulas	Yields in Bu./Acre	Percent Foliage Dead on Sept. 2
1. Zac X5 + DDT	6-1-100	534	32
2. Zac X6 + DDT	6-1-100	492	32
3. Zac S + DDT	3-1-100	528	30
4. Zac X6 + p.e.p.s. + DDT	6-.5-1-100	538	34
5. Zac X6 + Latex + DDT	6-1-100	573	31
6. Methasan S + DDT	3-1-100	538	32
7. Methasan W + DDT	1.5-1-100	527	29
8. Methasan B + DDT	1.5-1-100	512	32
9. Methasan B + DDT	.75-1-100	526	37
10. Methasan W + DDT	.75-1-100	526	33
11. Methasan W + p.e.p.s. + DDT	1.5-.5-1-100	538	30
12. Parzate Special + DDT	2-1-100	516	30
13. Parzate + DDT	2-1-100	560	31
14. Parzate + p.e.p.s. + DDT	2-.5-1-100	556	28
15. Parzate + Latex + DDT	2-1-1-100	531	42
16. Robertson Fungicide + DDT	2.2-1-100	525	44
17. Robertson Fungicide + p.e.p.s. + DDT	2.2-.5-1-100	525	43
18. Robertson Fungicide + p.e.p.s. + DDT	1.1-.5-1-100	526	44
19. Vancide 51 + DDT	3-1-100	509	38
20. Vancide + p.e.p.s. + DDT	3-.5-1-100	534	35
21. No treatment		462	77
Five fungicides only		523	35
Five Fungicides + p.e.p.s.		538	34
L.S.D. at 5% level		58	

Table 43. Yield and foliage condition of Cobbler potatoes when sprayed with various fungicides formulated in X and 4X concentrations at 160 and 40 gallons per acre, respectively. Early blight present.

Treatments	Formulas	Yield in Bu/Acre		% foliage dead Sept. 2	
		For each Treatment	Ave. for each Material	For each Treatment	Ave. for each Material
1. D-14 + $ZnSO_4$ + DDT*	4-1-2-100	334	345	47	48.5
2. "	16-4-8-100	355		50	
3. Parzate + DDT*	2-2-100	338	354	42	43.0
4. "	8-8-100	370		44	
5. Zerlate + DDT*	2-2-100	379	380	44	43.0
6. "	8-8-100	381		42	
7. Methasan W + DDT*	1.5-2-100	391	382	45	42.5
8. "	6-8-100	373		40	
9. Zac + DDT*	3-2-100	352	350	42	42.0
10. "	12-8-100	348		42	
11. Tribasic + DDT*	4-2-100	329	334	52	50.5
12 "	16-8-100	338		49	
13. COC-S + DDT*	4-2-100	329	331	56	57.5
14. "	16-8-100	333		59	
15. No treatment		300		91	
Averages of the two types of application					
160 g./acre (X)		342		49	
40 g./acre (4X)		357		49	
L.S.D. at 5% level		32			

*DDT was used as a 25% emulsifiable formulation.

Table 44. Yield and foliage condition of late-planted Cobbler potatoes when all fungicide-insecticide formulations were applied at 80 psi and 40 gallons per acre. Late blight severe and early blight of medium intensity.

Treatments	Formulas (2X)	Yields in Bu./Acre	Percent Foliage Dead on Sept.10
1. No treatment		337	97
2. Copper aerosol	8-8-100	470	26
3. Dithane Z-78 + DDT	8-4-100	429	37
4. " + parathion	8-4-100	430	44
5. " + Dilan	8-4-100	455	37
6. " + C 4049	8-4-100	483	40
7. Parzate + $ZnSO_4$ + DDT	8-4-8-100	524	19
8. Methasan S + DDT	12-8-100	453	50
9. Zac S + DDT	12-8-100	429	67
10. Robertson copper + DDT	8.8-8-100	457	32
11. Vancide 51 + DDT	12-8-100	433	62
12. COC-S + DDT	16-8-100	507	17
L.S.D. at 5% level		47	

Table 45. Comparative yields and foliage condition of late-planted Cobbler potatoes when sprayed with four different control formulations applied as concentrates with and without a supplemental air blast.
Both early and late blights present on the foliage.

Treatments	Formulas	Yield in Bu./Acre	Percent foliage Dead on Aug. 28
Applied without air			
1. Tribasic + DDT	16-4-100	520	32
2. " + parathion	16-4-100	555	30
3. Zerlate + DDT	8-4-100	540	39
4. " + parathion	8-4-100	530	38
Applied with air			
5. Tribasic + DDT	16-4-100	548	37
6. " + parathion	16-4-100	538	38
7. Zerlate + DDT	8-4-100	470	42
8. " + parathion	8-4-100	485	41
9. No treatment		365	60
Averages			
Applied without air		536	35
Applied with air		510	40
DDT		527	37
Parathion		520	38
Tribasic		540	34
Zerlate		506	40

Table 46. Effect of various insecticides on insect populations and yield of Irish Cobbler potatoes. Wooster, Ohio, 1948-1950.

Treatments And Year	Formulas	Leafhopper Nymphs Per Leaf	Flea Beetle Holes Per Leaflet	Aphid Population	Yield Per Acre
		No.	No.	Class 1/	Bu.
1948					
DDT	1-100	0	5	3	833
Methoxychlor	2-100	0	5	4	798
Rhothane	2-100	0	19	3	860
Chlordane	2-100	5.6	18	3	743
Lindane	1-100	5.9	8	1	792
Parathion	2-100	0	3	1	942
Untreated Check		15.9	206	2	362
1949					
DDT	1-100	0	19	3	506
Methoxychlor	2-100	0	18	4	496
Rhothane	2-100	0	22	3	475
Chlordane	2-100	0.7	16	3	508
Lindane	1-100	0.3	12	1	503
Toxaphene	2-100	0.2	16	2	535
Aldrin	1-100	2.9	5	3	406
Parathion	1-100	0	21	1	573
Dilan	1-100	0	14	3	522
Untreated Check		15.4	142	3	349
1950					
DDT	1-100	0	6	3	675
Methoxychlor	2-100	0	4	4	638
Malathion	2-100	0	12	1	649
EPN	0.6-100	0.2	9	2	645
Q 137	1-100	0	9	3	641
Aldrin	1-100	3.2	7	3	443
Pestox 3	2-100	0.5	14	1	578
Parathion	1-100	0	8	1	733
Dilan	1-100	0	8	3	688
Untreated Check		5.8	16	3	402

1/ Classes of aphid populations: 1= none; 2= trace; 3= light; 4= medium; 5= heavy.

Table 47. Potato yields and foliage scores when Cobblers were sprayed with an identical series of treatments at Marietta, Wooster, and Willard in 1951. Early blight was of medium severity at Marietta and Wooster, and more destructive at Willard. Late blight was virtually absent at all three locations.

Treatments	Formulas	Yields in Bu./Acre				%Foliage Dead 20 Days Before Harvest			
		Marietta	Wooster	Willard	Ave.	Marietta	Wooster	Willard	Ave.
1. No treatment		314	436	475	408	86	55	80	74
2. Tribasic + DDT	4-1-100	362	482	503	449	50	30	60	47
3. " + parathion	4-1-100	372	470	506	449	52	25	57	45
4. " + C 4049 W.P.	4-1-100	350	494	516	453	57	33	57	49
5. " + C 4049 Em.	4-1-100	347	451	514	437	56	32	45	44
6. " + Dilan	4-1-100	372	507	484	454	56	25	55	45
7. " + Systox	4-1-100	370	485	502	452	50	30	60	47
8. " + Pestox	4-1-100	364	448	521	444	53	27	63	48
9. " + Metacide	4-1-100	361	510	530	467	53	30	45	43
10. " + p.e.p.s. + DDT	4-.5-1-100	380	527	523	477	42	20	48	37
11. Cop-O-Zinc (42% Cu) + DDT	4-.5-1-100	382	499	517	466	37	19	52	36
12. CHCO + p.e.p.s. + DDT	4-.5-1-100	372	511	563	482	50	26	50	42.
13. Robertson Fungicide + DDT	2.5-.5-1-100	350	518	536	468	54	28	50	44
14. Copper cupferron + DDT	3-1-100	383	539	530	484	54	21	35	37
15. Crag 658 + DDT	2-1-100	387	515	527	476	50	21	53	41
16. Compound 1217 + DDT	7-1-100	370	521	547	479	57	25	65	49
17. Zerlate + DDT	2-1-100	391	536	527	488	50	18	35	34
18. SDD + $ZnSO_4$ + DDT	4-1-1-100	394	542	531	489	35	16	30	27
19. SDD-A+$ZnSO_4$ + DDT	4-1-1-100	395	563	532	497	34	16	30	27
20. D-14 + " + DDT	4-1-1-100	396	560	554	503	30	16	30	25
21. Vancide 51 + $ZnSO_4$ + DDT	4-1-1-100	407	542	564	504	36	16	30	27
22. SEBD + $MnSO_4$ + DDT	4-1-1-100	389	536	550	492	42	22	27	30
23. Dithane Z-78 + DDT	2-1-100	391	533	552	490	35	19	32	29
24. Manzate + DDT	2-1-100	389	544	538	490	43	19	30	31
25. OS377D + DDT	4-1-100	336	484	498	439	62	30	37	43
L.S.D. at 5% level		29	34	53					

Table 48. Influence of formulation on the performance of various fungicides applied to Cobbler potatoes at Wooster in 1951. Early blight of medium severity. Late blight absent.

Treatments*	Formulas	Yield in Bu./Acre	Percent Foliage dead On August 5
1. No treatment		444	55
2. Methasan W	1.5-1-100	503	21
3. Methasan S	3-1-100	531	17
4. SDDC + $ZnSO_4$	4-1-1-100	566	20
5. Zac W	6-1-100	515	23
6. Zac S	3-1-100	512	23
7. SDDC-A + $ZnSO_4$	4-1-1-100	531	19
8. SDDC-A + $ZnSO_4$ + F1068	4-1-0.5-100	513	21
9. Vancide 51 + $ZnSO_4$	4-1-1-100	541	20
10. Vancide 51 + Kolofog	4-1-1-100	533	26
11. Vancide 632	2-1-100	537	21
12. Vancide 935	4-1-100	503	36
13. Robertson Fungicide	2.5-1-100	494	34
14. Robertson Fungicide + F1068	2.5-0.5-1-100	498	28
15. Robertson Fungicide + Bentonite	2.5-1-1-100	503	31
16. CRTCO	3-1-100	465	31
17. CHCO + F1068	3-0.5-1-100	453	32
18. CHCO + Soy flour	3-0.5-1-100	473	35
19. Manzate	2-1-100	483	26
20. Manzate + p.e.p.s.	2-0.5-1-100	489	24
21. D-14 + $ZnSO_4$	4-1-1-100	484	25
22. D-14 + $MnSO_4$	4-1-1-100	476	29
23. Dithane Z-78	2-1-100	527	28
24. COC-S	4-1-100	493	30
25. COC-S + $ZnSO_4$	4-1-1-100	487	28
26. COC-S + p.e.p.s.	4-0.5-1-100	475	36
27. COC-S - Cl	4-1-100	473	39
28. Baycar	2-1-100	493	44
29. Copper hydrate	3.5-1-100	490	28
30. Phelps-Dodge copper paste	4-1-100	503	31
L.S.D. at 5% level		38	

*DDT used with all treatments.

Table 49. Comparative performance of various fungicides, some of which were differently formulated, in the control early blight, (which became severe) on late-planted Katahdin potatoes grown at Wooster in 1951. Late blight did not appear.

Treatments	Formulas	Yield in Bu./Acre	Percent Foliage Dead on Sept.25
1. No treatment		424	100
2. Tribasic + DDT	4-1-100	491	57
3. Tribasic + p.e.p.s. + DDT	4-0.5-1-100	520	45
4. COC-S + DDT	4-1-100	544	44
5. COC-S - Cl + DDT	4-1-100	510	57
6. Copper hydrate + DDT	3.5-1-100	546	60
7. Robertson fungicide + DDT	2.5-1-100	487	52
8. CHCO + DDT	3-1-100	514	49
9. Copper cupferron + DDT	3-1-100	515	46
10. Cop-O-Zinc + DDT	4-1-100	499	36
11. Crag 658 + DDT	2-1-100	494	47
12. Crag 1217 + DDT	7-1-100	482	62
13. Zerlate + DDT	2-1-100	566	49
14. Methasan S + DDT	3-1-100	590	25
15. SDDC + $ZnSO_4$ + DDT	4-1-1-100	570	34
16. SDDC-A + $ZnSO_4$ + DDT	4-1-1-100	590	29
17. D-14 + $ZnSO_4$ + DDT	4-1-1-100	596	27
18. D-14 + $MnSO_4$ + DDT	4-1-1-100	601	52
19. Vancide 51 + $ZnSO_4$ + DDT	4-1-1-100	568	38
20. Dithane Z-78 + DDT	2-1-100	573	27
21. Manzate + DDT	2-1-100	572	31
22. Baycar + DDT	2-1-100	457	85
23. OS 377 + DDT	4-1-100	438	91
24. Bordeaux + DDT	8-8-1-100	494	40
25. No. 17 =4 appl. - Then No. 24 to end of season		480	30
26. AS No. 25, but DDT omitted after 4 appl.		464	30
27. No.17 = 6 appl. - Then No. 24 to end of season		522	25
L.S.D. at 5% level		32	

Table 50. Comparison of four copper-containing and four organic fungicides in "X" and "4X" concentrations, applied at 160 and 40 gallons per acre, respectively, and of fixed coppers with and without the addition of p.e.p.s. Cobbler potatoes grown at Wooster. Early blight only.

Treatments*	Formulas	Yields in Bu./Acre: Treat-ments	Yields in Bu./Acre: Materials ave.	Percent foliage dead on Aug. 5: Treat-ments	Percent foliage dead on Aug. 5: Materials ave.
1. Tribasic	4-1-100	418		60	
2. "	16-4-100	411	415	62	61.0
3. COC-S	4-1-100	413		59	
4. "	16-4-100	411	412	61	60.0
5. Copper A	4-1-100	415		60	
6. "	16-4-100	406	411	61	60.5
7. Crag 658	2-1-100	411		60	
8. "	8-4-100	438	425	57	58.5
9. Zerlate	2-1-100	451		57	
10. "	8-4-100	445	448	57	57.0
11. Parzate	2-1-100	465		57	
12. "	8-4-100	472	469	50	53.5
13. Manzate	2-1-100	467		52	
14. "	8-4-100	476	472	51	51.5
15. Baycar	2-1-100	394		65	
16. "	8-4-100	401	398	62	63.5
17. Tribasic + p.e.p.s.	4-1-1-100	443		61	
18. COC-S	4-1-1-100	409		61	
19. Copper A	4-1-1-100	408		57	
20. Crag 658	2-1-1-100	433		52	
L.S.D. at 5% level		33			
Concentration Averages					
X (8 treatments)		418		58.2	
4X (")		433		56.4	
X (coppers)		414		59.8	
4X (")		417		60.3	
X (organics)		444		56.5	
4X (")		449		55.0	
X coppers + p.e.p.s.		423		57.8	

*DDT used with all treatments.

Table 51. Concentrate (4X) versus regular (X) formulations of various fungicides in the control of early blight at Willard. These data are an extension of Table 50 for 1951 and the lower number treatments are from that table.

Concentration Numbers		Treatments (Materials)	Yield in Bu./Acre		% Defoliation	
X	4X		X	4X	X	4X
2	30	Tribasic + DDT	503	523	60	52
3	31	" + parathion	506	528	57	42
6	32	" + Dilan	484	523	55	37
4	33	" + C 4049	516	528	57	42
11	34	Cop-O-Zinc + DDT	517	522	52	25
15	35	Crag 658 + DDT	527	521	52	32
17	36	Zerlate + DDT	527	523	35	25
21	37	Vancide 51 + DDT	564	555	30	35
24	38	Manzate + DDT	538	543	30	22
23	39	Z-78 + DDT	552	563	32	22
25	40	OS 377 + DDT	498	518	37	47
Averages of treatments			521	532	45	35
1. The untreated check at Willard, from Table 47.			475		80	

Table 55. Effect of various "dithiocarbamate" formulations on disease control and yield of Katahdin potatoes, and the influence of p.e.p.s. on the performance of two fixed coppers and two dithiocarbamate compounds. Blights scarce.

Treatments	Formulas	Yield in Bu./Acre	Percent Foliage Dead on Oct. 6
1. Dithane Z-78 + DDT	2-1-100	407	42
2. D-14 + $ZnSO_4$ + DDT	4-1-1-100	399	45
3. D-14 + $MnSO_4$ + "	4-1-1-100	408	47
4. D-14 + $ZnSO_4$ + $MnSO_4$ + DDT	4-.5-.5-1-100	394	45
5. Dithane Special + $ZnSO_4$ + DDT	4-1-100	395	44
6. Manzate + DDT	2-1-100	413	40
7. Tribasic + DDT	4-1-100	392	68
8. COC-S + DDT	4-1-100	384	72
9. Dithane Z-78 + p.e.p.s. + DDT	2-.5-1-100	404	40
10. Manzate + p.e.p.s. + DDT	2-.5-1-100	410	40
11. Tribasic + p.e.p.s. + DDT	4-.5-1-100	395	56
12. COC-S + p.e.p.s. + DDT	4-.5-1-100	398	53
13. No treatment		302	92
L.S.D. at 5% level		16	

Table 52. Combination fungicide-insecticide mixtures used at X (regular) and 4X (concentrated) formulations on Cobbler potatoes at Wooster in 1951 for the control of foliage diseases. Early blight present, late blight absent.

Treatments	Formulas	Yield in Bu./Acre	Percent Foliage Dead on Aug. 10	Number Flea Beetle Holes Per Leaflet On July 27
"X" concentration				
COC-S + DDT	4-1-100	381	70	104
" + C 4049	4-1-100	372	74	106
Manzate + DDT	2-1-100	385	64	108
" + C4049	2-1-100	395	55	126
"4X" concentration				
COC-S + DDT	16-4-100	445	59	103
" + C 4049	16-4-100	426	75	109
Manzate + DDT	8-4-100	419	70	125
" + C 4049	8-4-100	389	62	129
No treatment		333	97	141
L. S. D. at 5% level		30		
Averages				
"X" concentrations		383	66	111
"4X" concentrations		420	67	117
Treatment averages				
COC-S		405	70	106
Manzate		397	63	122
DDT		407	66	110
C 4049		396	67	118
COC-S X		377	72	105
4X		435	67	106
Manzate X		390	60	116
4X		404	66	127

Table 53. Comparative effect of various fungicides and insecticides, and variations in formulation of some of them on disease and insect control and the resulting yields on Cobbler potatoes at three different locations in Ohio in 1952.

Treatments*	Formulas	Yields in Bu./Acre				Percent defoliation near end of growth period at each location.			
		Marietta	Wooster	Willard	Ave.	Marietta	Wooster	Willard	Ave.
1. No treatment		300	218	395	304	66	50	65	60
2. Zerlate	2-100	382	316	457	385	39	28	31	33
3. " + p.e.p.s.	2-.5-100	402	341	495	413	36	23	28	29
4. SDD + $ZnSO_4$	2-1-100	402	326	485	404	32	18	30	27
5. Parzate	2-100	413	310	494	406	33	27	27	29
6. Parzate + p.e.p.s.	2-.5-100	416	327	496	413	31	24	26	27
7. L. Parzate + $ZnSO_4$	4-1-100	390	283	456	376	33	26	31	30
8. Manzate	2-100	406	302	462	390	35	28	32	32
9. L. Parzate + $MnSO_4$	4-1-100	374	320	446	380	42	27	45	38
10. Vancide 51 ZW	2-100	397	279	433	370	40	28	30	33
11. Vancide 51 + $ZnSO_4$	4-1-100	384	281	458	374	36	27	31	31
12. Tribasic	4-100	393	256	411	350	36	36	47	40
13. " + p.e.p.s.	4-.5-100	401	272	429	367	36	30	43	36
14. " + National Stk.	4-2-100	378	288	428	365	37	33	49	40
15. " + Vancide "	4-.5-100	399	292	446	379	36	33	47	39
16. Calumet CHO	3-100	383	292	437	371	39	36	42	39
17. " + Kaysoy	3-1-100	386	264	436	362	42	34	42	39
18. " + Furafil	3-1-100	368	244	424	345	41	40	50	44
19. XP-63	4-100	336	267	405	336	46	29	44	39
20. XP-90	4-100	344	268	401	338	44	34	53	44
21. Parzate + Aldrin	2-1-100	425	287	435	382	32	31	28	30
22. " + dieldrin	2-1-100	414	313	445	391	33	22	24	26
23. " + malathion W. P.	2-2-100	398	263	483	381	34	31	29	31
24. " + " Em.C.	2-1-100	388	281	466	378	33	28	29	30
25. " + Systox	2-1-100	396	282	494	391	34	25	25	28
L.S.D. at 5% level		15	23	25					

*DDT used with all treatment at 2/3-100 unless otherwise indicated.

Table 54. Yield and defoliation of Cobbler potatoes when sprayed with various old and new fungicides at Wooster in 1952.

Treatments*	Formulas	Yield in Bu./Acre	Percent Defoliation on Aug. 1
1. Zerlate	2-100	229	44
2. " + Parzate	1-1-100	251	39
3. SDD + $ZnSO_4$	2-1-100	251	27
4. " + D-14 + $ZnSO_4$	1-2-1-100	284	28
5. Dithane Z-78	2-100	244	35
6. D-14 + $ZnSO_4$	4-1-100	244	38
7. " + ($ZnSO_4$ + $CuSO_4$, 9-1)	4-.9-.1-100	248	33
8. " + ($ZnSO_4$ + $MnSO_4$, 1-1)	4-.5-.5-100	243	35
9. " + (Sn + Mn + Fe + Cu Sulfates, 5-3-1-1)	4-.5-.3-.1-.1-100	254	40
10. Manzate	2-100	266	39
11. D-14 + $MnSO_4$	4-1-100	245	43
12. SDD + $MnSO_4$	2-1-100	250	40
13. Zac	5-100	243	34
14. SDD (CHA) + $ZnSO_4$	4-1-100	263	29
15. Fermate	2-100	227	37
16. SDD + $FeSO_4$	2-1-100	235	40
17. D-14 + "	4-1-100	232	42
18. Vancide 51 ZW	2-100	231	39
19. " + $ZnSO_4$	4-1-100	266	32
20. Vancide 995	2-100	246	38
21. Vancide 51 + $MnSO_4$	4-1-100	227	43
22. Vancide 1096	2-100	249	36
23. Sporcop (Cu Naph + Oil)	8-100	205	42
24. Mercupron	4-100	212	37
25. "	2-100	208	51
26. 50-CS-46	0.5-100	208	46
27. B-36	2-100	234	32
28. B-59	2-100	233	41
29. B-160	2-100	218	45
30. Thiolutin + Tween	23 gm-.5-100	228	47
31. Rimocidin + "	23 gm-.5-100	213	49
32. Terramycin + "	23 gm-.5-100	203	46
33. Tribasic	4-100	237	41
34. " P 34.1	4-2-100	237	41
35. No treatment		168	78
L.S.D. at 5% level		26	

*DDT used at 2/3-100 with all treatments.

Table 56. Influence of spray schedule variations and harvest dates on the yield and specific gravity of Katahdin potatoes at Wooster in 1952.

Treatments	Formulas	Yield in Bu./Acre on Sept. 26	Oct. 3	Oct. 10	Ave.	Percent Foliage Dead on Oct. 6	Average Specific Gravity of Tubers
1. Bordeaux only	8-6-100	321	328	341	330	76	1.088
2. Bordeaux + DDT	8-6-2/3-100	361	384	380	375	68	1.087
3. D-14 + $ZnSO_4$ + DDT	4-1-2/3-100	368	390	393	384	48	1.084
4. No. 3 = 4 appl. - Then drop DDT		377	407	409	398	50	1.087
5. No. 3 = 4 appl. - Then No. 1 = 4 appl.		380	410	414	401	61	1.083
6. No treatment		290	293	302	296	92	1.084

Table 57. Influence of pressure-gallonage variations on disease control and yield of Cobbler and Russet potatoes when sprayed with Manzate at Wooster in 1952.

Treat-ment No.	Gals. per acre	Nozzle type	Number of nozzles per 5½' space	Forward speed m.p.h.	Pressure p.s.i.	Formulas	Nozzle code number	Yield in Bu./Acre	Percent Foliage Dead on Sept.22
Cobblers									
1	160	Flat	4	2	56	2-100	9508	374	70
2	80	"	4	4	56	4-100	"	401	70
3	40	"	4	4	56	8-100	6504	403	66
4	30	"	3	4	56	11-100	8004	394	72
5	20	"	2	4	56	16-100	"	379	70
6	10	"	1	4	56	32-100	9504	368	79
7	40	"	3	3	56	8-100	8004	395	74
8	40	"	2	2	56	8-100	9504	398	65
9	40	"	1	2	56	8-100	9508	383	71
10	40	Cone	4	4	50	8-100	D6-25C	383	67
11	40	"	3	3	50	8-100	"	373	70
12	40	"	2	2	50	8-100	"	395	67
13	40	"	1	2	50	8-100	D10-25C	367	76
14	20	"	2	4	50	16-100	D6-25C	388	67
15	10	"	1	4	50	32-100	"	375	69
16	No treatment						"	290	97
L.S.D. at 5% level								27	
Russets									
1	160	Flat	4	2	56	2-100	9508	388	40
2	80	"	4	4	56	4-100	"	388	42
3	40	"	4	4	56	8-100	6504	385	38
4	20	"	2	4	56	16-100	8004	386	40
5	40	Cone	4	4	50	8-100	D6-25C	382	41
6	20	"	2	4	50	16-100	"	383	45
7	40	Flat	3	3	56	8-100	8004	398	43
8	40	"	2	2	56	8-100	9504	418	40
9	40	"	1	2	56	8-100	9508	409	46
10	40	Cone	2	2	50	8-100	D6-25C	394	45
11	40	"	3	3	50	8-100	"	402	43
12	40	Flat	2	2	56	8-100	9504	410	40
13*	40	"	2	2	56	8-100	"	418	42
14*	40	"	2	2	56	16-100	"	391	50
15*	No treatment							324	96
L.S.D. at 5% level								40	

* Treatment 13 = Zerlate, 14 = Dithane Z-78, and 15 = Tribasic

Table 58. Comparative performance of various fungicide-insecticide formulations in the control of diseases and insects on Cobbler potatoes at Marietta, Wooster and Willard in 1953.

Treatments	Formulas	Yield in Bu./Acre at Marietta	Yield in Bu./Acre at Wooster	Yield in Bu./Acre at Willard	Yield in Bu./Acre at Ave.	Percent foliage dead at Marietta	Percent foliage dead at Wooster	Percent foliage dead at Willard	Percent foliage dead at Ave.
1. No treatment		335	160	318	271	65	60	50	58
2. Dithane Z-78 + DDT	2-1-100	423	231	370	341	44	24	24	31
3. " + Dieldrin + DDT	2-.5-1-100	433	243	388	355	32	25	30	29
4. " "	2-1-100	426	220	382	343	39	28	28	32
5. Nos. 4 and 2 alternating		434	251	373	353	34	24	28	29
6. " + Strobane	2-4-100	356	219	354	310	35	24	41	33
7. " + Aldrin	2-2.5-100	404	217	373	331	43	27	29	33
8. Lo-738 + DDT	2-1-100	418	237	365	340	41	27	32	33
9. Zerlate + DDT	2-1-100	396	222	378	332	48	25	32	35
10. T-M ziram + DDT	3-1-100	390	214	348	317	49	27	41	39
11. SDD + $ZnSO_4$ + DDT	2-1-100	421	230	360	337	42	22	28	31
12. SDD + " + "	2-1-.5-100	409	235	387	344	39	25	35	33
13. Manzate + DDT	2-1-100	418	224	380	341	42	27	25	31
14. D-14 + $MnSO_4$ + DDT	4-1-1-100	404	212	376	331	45	31	38	38
15. B-160 (W.P.)	4-1-100	385	216	348	316	51	32	44	42
16. B-160 (Tank-mix) A + B + DDT	8-1.5-1-100	384	203	366	318	48	36	33	39
17. Al-119 + DDT	2-100	362	192	346	300	53	36	40	43
18. FF-10 + "	4-100	391	210	361	321	49	35	30	38
19. Tribasic + DDT	4-1-100	390	192	357	313	52	36	33	40
20. " + K704 + DDT	4.5-1-100	399	214	356	323	52	32	38	41
21. " + p.e.p.s. + DDT	4-.5-1-100	383	200	366	316	50	35	42	42
22. Cop-O-Zinc + DDT	4-1-100	390	212	343	315	43	26	42	37
23. Cop-O-Mang. + DDT	4-1-100	400	209			48	28		
24. Copper Naph. 4% + DDT	4-1-100	390	192			47	40		
25. Cunilate 2472 + DDT	4-1-100	379	196			56	37		
L.S.D. at 5% level									

Table 59. Comparative performance of various old and new fungicides in the control of early blight on potatoes at Wooster in 1953. (6 replicates used)

Treatments	Formulas	Yield in Bu./Acre	Percent Foliage Dead. Ave. 3 scores
1. Dithane Z-78 + DDT	2-1-100	217	32
2. Lo-738 + DDT	2-1-100	211	37
3. He-177 + "	2-1-100	217	35
4. Zerlate + DDT	2-1-100	229	29
5. T-M ziram + DDT	2.5-1-100	231	26
6. SDD + $ZnSO_4$ + DDT	2-1-1-100	244	27
7. SDD + " + K704 + DDT	2-1-.5-1-100	241	24
8. SDD + " + DDT (Emul.)	2-1-2-100	237	26
9. Manzate + DDT (W.P.)	2-1-1-100	231	33
10. D-14 + $ZnSO_4$ + DDT	4-1-1-100	219	30
11. " + $MnSO_4$ + "	4-1-1-100	214	33
12. Al-119 +DDT	3-1-100	195	41
13. FF-10 + "	3-1-100	195	42
14. B-160 (W.P.) + DDT	4-1-100	210	39
15. B-397 (10%) + "	30-1-100	193	36
16. B-622 + DDT	1-1-100	221	35
17. Cop. Naph. (8% Cu) + DDT	4-1-100	193	33
18. No treatment		168	56
L.S.D. at 5% level		12	

Table 60. Comparative performance of a number of new fungicidal formulations in the control of early blight on Cobbler potatoes at Wooster in 1953. DDT (1-100) was used in all treatments.

Treatments	Formulas	Yield in Bu./Acre	Percent Foliage Dead on July 24
1. Al-118	2-100	178	50
2. Al-119	2-100	196	49
3. FF-9	4-100	195	52
4. FF-10	4-100	207	50
5. FF-11	4-100	193	51
6. FF-12	4-100	208	53
7. Copper Naph. (2706)	6-100	207	44
8. Copper Resinate (2704)	8-100	205	47
9. Cunilate (2472)	6-100	205	47
10. Cunizone (2529)	6-100	202	42
11. B-160 (W.P.)	4-100	193	47
12. B-160 Tank-mix (A + B)	8-1.5-100	204	47
13. B-160 Tank-mix (A + B) + p.e.p.s.	8-1.5-.5-100	197	52
14. B 397 (10%)	30-100	200	55
15. No treatment		165	65
L.S.D. at 5% level		25	

Table 61. Influence of various adhesives on the performance of various fungicides in the control of a light infection of early blight on potatoes at Wooster in 1953. Six replicates used.

Treatments	Formulas	Yield in Bu./Acre	Percent Foliage Dead on Sept.23
1. Tribasic + DDT	4-1-100	161	44
2. " + p.e.p.s. + DDT	4-.5-1-100	171	42
3. " + Veg-Oil + "	4-.5-1-100	171	41
4. " + Vancide Stk. + DDT	4-.5-1-100	172	39
5. " + K704 + DDT	4-.5-1-100	171	37
6. Robertson Fung. + DDT	2.5-1-100	167	42
7. " " + K704 + DDT	2.5-1-100	174	37
8. CHCO + DDT	3-1-100	173	39
9. CHCO + K704 + DDT	3-.5-1-100	169	35
10. Manzate + DDT	2-1-100	180	36
11. " + "	1.5-1-100	160	46
12. " + K704 + DDT	1.5-.5-1-100	179	35
13. No treatment		150	50
L.S.D. at 5% level		12	

Table 62. Comparative effect of wettable powder and emulsifiable concentrate formulations of DDT on the efficacy of various fungicides for the control of potato diseases.

Treatments	Formulas	Yield in Bu./Acre	Percent Foliage Dead on Oct. 2
1. Zerlate + DDT (W.P.)	2-1-100	355	64
2. " + " (Emul.)	2-2-100	356	70
3. T-M ziram + DDT (W.P.)	2.5-1-100	353	82
4. SDD + $ZnSO_4$ + DDT (W.P.)	2-1-1-100	343	60
5. SDD + " + " (Emul.)	2-1-2-100	333	62
6. SDD-D + $ZnSO_4$ + DDT (Emul.)	2-1-2-100	348	63
7. Manzate + DDT (Emul.)	2-2-100	342	58
8. " + Cal. Arsenate	2-4-1-100	345	70
9. No treatment		305	85
L.S.D. at 5% level		23	

Table 63. Influence of spray-schedule variations on the yield and specific gravity of Katahdin potatoes grown at Wooster in 1953.

Treatments	Formulas	Yield in Bu./Acre	Percent Foliage Dead on Oct. 12	Specific gravity
1. Bordeaux only	8-8-100	224	50	1.0795
2. Bordeaux + DDT	8-8-1-100	233	45	1.0810
3. Dithane D-14 + $ZnSO_4$ + DDT	4-1-1-100	255	40	1.0818
4. No. 3 to mid-season-Then No. 2		251	55	1.0815
5. No treatment		216	80	1.0812
L.S.D. at 5% level		14		

Table 64. Influence of gallonage, pressure, and nozzle type on the control of diseases and insects on Cobbler potatoes at Wooster in 1953. Standard treatment on basis of 160 g.p.a. of Manzate + DDT in a 2-1-100 formulation. (6 replicates used).

Treatment No.	Gals. per acre	Specifications of Application: Concentration in terms of "X"	Number of nozzles on 5½' swath	Nozzle type	P.S.I.	Yield in Bu./Acre	Percent Foliage Dead
1	100	1	4	Cone	300	237	32
2	80	2	4	"	200	243	33
3	80	2	4	Flat	200	252	28
4	40	4	2	"	60	249	28
5	30	5.3	2	"	60	221	33
6	20	8	2	"	60	235	33
7	10	16	1	"	60	197	34
8	40	4	2	Cone	60	239	31
9	20	8	2	"	60	231	30
10	40	4	2	Flat	20	205	31
11	40	4	2	"	40	235	31
12	40	4	2	"	80	239	28
13	40	4	2	"	100	232	28
14	80	2	4	"	200	263	25
15	15	10.7	2	"	60	236	31
16	50	3.2	2	"	60	246	32
17	No treatment					179	49
	L.S.D. at 5% level (19:1)					13	

Table 65. Relationship of gallonage, pressure, and resulting droplet size to disease and insect control on Katahdin potatoes at Wooster in 1953. Standard treatment on basis of 160 g.p.a. of Manzate + DDT in a 2-1-100 formulation. (6 replicates used).

Treatment No.	Gals. per acre	Specifications of Application: Concentrations in terms of "X"	P.S.I.	Formulas	Yield in Bu./Acre	Percent Foliage Dead on Oct. 12
1	80	2.0	80	4-100	208	65
2	60	2.7	80	5.4-100	207	67
3	40	4.0	80	8-100	224	70
4	20	8.0	80	16-100	212	75
5	40	4.0	100	8-100	210	62
6	40	4.0	60	8-100	205	65
7	40	4.0	40	8-100	209	75
8	40	4.0	20	8-100	198	80
9	80	2.0	40	4-100	207	70
10	80	2.0	60	4-100	210	73
11	80	2.0	80	4-100.	219	60
12	80	2.0	100	4-100	225	68
13	No treatment				140	95
	L.S.D. at 5% level				16	

Table 66. Comparative performance of various fungicide-insecticide formulations in the control of early blight on Cobbler potatoes grown at three locations in Ohio in 1954.

Treatments	Formulas	Yields in Bu./Acre at				Percent foliage dead at			
		Marietta	Wooster	Willard	Ave.	Marietta	Wooster	Willard	Ave.
1. Dithane Z-78 + DDT	2-1-100	599	185	513	432	42	33	29	35
2. " + D-d*	2-1-100	577	173	530	427	44	29	27	33
3. " + endrin	2-1-100	583	171	541	432	41	33	30	32
4. " + Systox	2-.25-100	584	188	516	429	44	31	29	35
5. " + Orthophos	2-.33-100	577	192	520	430	44	31	28	34
6. " + Strobane	2-4-100	530	179	507	405	45	34	33	37
7. Lo-738 + D-d	2-1-100	581	198	512	430	50	32	40	41
8. He-177 + "	2-1-100	561	181	491	411	54	32	40	42
9. M-22 + "	2-1-100	619	186	534	446	45	40	25	37
10. SDD + $ZnSO_4$ + D-d	2-1-1-100	568	187	520	425	49	26	27	34
11. SDD + " + $CuSO_4$ + D-d	2-.5-.5-1-100	563	188	507	419	50	36	34	40
12. SDD + D-14 + $ZnSO_4$ + "	1-2-1-1-100	582	183	525	430	46	33	23	34
13. Tribasic + D-d	4-1-100	553	185	471	403	56	37	43	45
14. Cop-O-Manganese + D-d	4-1-100	542	167	481	397	56	37	47	47
15. Tennam + D-d	2-1-100	584	175	533	431	56	34	34	41
16. OS-510 + "	2-1-100	544	171	450	388	51	31	51	44
17. WL-136 + "	2-1-1-100	507	164	469	380	59	33	60	51
18. Dithane Z-78 + D-d	8-4-100	533	179	458	396	56	34	48	46
19. M-22 + D-d	8-4-100	571	168	509	416	56	39	38	44
20. Tribasic + D-d	16-4-100	526	190	473	396	58	29	53	47
21. He-177 + "	8-4-100	542	180	471	398	68	40	48	52
22. No treatment		482	170	420	357	74	47	78	66
L.S.D. at 5% level (19:)		33	N S	35					

* D-d = DDT + dieldrin formulated in 2-1 ratio.

Table 67. Influence of variations in pressure, volume, droplet size and nozzle design on disease and insect control on Cobbler potatoes at Wooster in 1954. Early blight scarce. Control treatment on all plots was Dithane M-22 + D-d in a basic 2-1-100 formulation.

Treatments	Gals. per acre	Concentration in terms of "X"	Spray pattern (nozzle type)	P.S.I.	Yield in Bu./Acre	Percent Foliage Dead
1	40	4	Flat	200	298	50
2	40	4	"	100	284	53
3	40	4	"	80	289	47
4	40	4	"	60	289	51
5	40	4	"	20	287	48
6	80	2	"	60	284	47
7	60	2.7	"	60	279	44
8	30	5.3	"	60	283	39
9	20	8.0	"	60	281	47
10	10	16.0	"	60	287	42
11	40	4	"	40	281	47
12	40	4	"	40	282	52
13	40	4	"	40	278	53
14	40	4	"	40	287	42
15	40	4	"	40	277	50
16	20	8	Cone	60	290	45
17	40	4	"	60	287	47
18	80	2	"	60	303	46
19	160	1	"	300	281	48
20	No treatment				269	67
	L.S.D. at 5% level				N.S.	

Table 68. Influence of pressure-volume (droplet size) variations on disease and insect control on Katahdin potatoes at Wooster in 1954. Early blight was of medium severity. Dithane Z-78 + D-d in a basic 2-1-100 formulation was used in all treatments.

Treatments	Gals. per acre	Concentration in terms of "X"	Spray pattern (nozzle type)	P.S.I.	Yield in Bu./Acre	Percent Foliage Dead
1	160	X	Cone	300	467	32
2	80	2X	Flat	200	463	37
3	40	4X	"	100	458	38
4	20	8X	"	60	474	34
5	40	4X	"	80	456	39
6	40	4X	"	60	482	32
7	40	4X	"	40	479	32
8	40	4X	"	20	466	32
9	80	2X	"	60	468	31
10	60	2.7X	"	60	455	37
11	30	5.3X	"	60	461	39
12	No treatment				371	98
	L.S.D. at 5% level				33	

Table 69. Comparative performance of several old and new fungicides in the control of early blight on Irish Cobblers at Wooster in 1954. Season dry and blight comparatively mild.

Treatments	Formulas	Yield in Bu./Acre	Percent Foliage Dead
1. Tribasic + D-d	4-1-100	211	42
2. Tennam 10 + D-d	2-1-100	203	32
3. Cop-O-Manganese + D-d	4-1-100	210	43
4. OS-510 + D-d	2-1-100	203	39
5. WL-136 + F. Stk. + D-d	2-1-100	218	37
6. B-64 + D-d	2-1-100	219	37
7. FF-31 + D-d	2-1-100	198	46
8. T-120 + "	2-1-100	206	40
9. Z-78 + "	2-1-100	210	43
10. Lo-738 + D-d	2-1-100	214	33
11. He-177 + "	2-1-100	246	40
12. Dithane M-22 + D-d	2-1-100	237	35
13. SDD + $ZnSO_4$ + D-d	2-1-1-100	246	37
14. SDD + $ZnSO_4$ + $CuSO_4$ + D-d	2-.5-.5-100	229	36
15. SDD + $MnSO_4$ + D-d	2-1-1-100	190	37
16. SDD + D-14 + $ZnSO_4$ + D-d	1-2-1-100	214	38
17. No treatment		181	50
L.S.D. at 5% level		19	

Table 70. Comparative effectiveness of a number of new fungicide formulations in the control of early blight on Katahdin potatoes at Wooster in 1954. Disease of more than average severity.

Treatments	Formulas	Yield in Bu./Acre	Percent Foliage Dead
1. OS-510 + D-d	2-1-100	417	49
2. T-120 + "	2-1-100	387	66
3. FF-31 + "	2-1-100	399	64
4. B-46 + "	2-1-100	434	60
5. WL-136 + F. Stk. + D-d	2-1-1-100	414	59
6. Z-78 + D-d	2-1-100	456	35
7. He-177 + D-d	2-1-100	434	29
8. Lo-738 + "	2-1-100	461	34
9. SDD + $ZnSO_4$ + D-d	2-1-1-100	435	30
10. SDD + " + $CuSO_4$ + D-d	2-.5-.5-1-100	408	34
11. SDD + D-14 + $ZnSO_4$ + "	1-2-1-1-100	413	36
12. 5SC 842 + D-d	2.5-1-100	389	69
13. No treatment		32	98
L.S.D. at 5% level		32	

Table 71. Effect of various control formulations on the yield and specific gravity values of Katahdin and Russet potatoes at Wooster in 1954 during a very dry, warm growing season.

Treatments	Formulas	Katahdin		Russet	
		Yield in Bu./Acre	Specific gravity	Yield in Bu./Acre	Specific gravity
1. Bordeaux only	8-8-100	489	1.0837	425	1.0791
2. " + D-d	8-8-1-100	527	1.0812	391	1.0798
3. Dithane Z-78 + D-d	2-1-100	582	1.0820	516	1.0801
4. No. 3 for 5 appl. - Then drop D-d		538	1.0836	502	1.0808
5. No. 3 for 5 appl. - Then No. 2		511	1.0830	425	1.0777
6. No. 3 for 7 appl. - Then No. 1		525	1.0803	440	1.0775
7. No treatment		572	1.0823	537	1.0799
8. SDD + $ZnSO_4$ + D-d	2-1-1-100	540	1.0795	507	1.0755
9. SDD + " + $CuSO_4$ + D-d	2-.5-.5-1-100	560	1.0828	463	1.0768
10. SDD + " + Tribasic + D-d	1-.5-2-1-100	509	1.0800	457	1.0780
11. Tribasic + D-d	4-1-100	510	1.0824	442	1.0810
12. He-177 + D-d	2-1-100	478	1.0822	439	1.0787
13. No. 3 + maleic hydrazide 6th appl.		534	1.0819	442	1.0833
14. No treatment		516	1.0788	438	1.0762

Table 72. Effect of various insecticides on insect populations and yield of Irish Cobbler potatoes. Wooster, Ohio, 1951-1954.

Treatments And Year	Formulas	Leafhopper Nymphs Per Leaf	Flea Beetle Holes Per Leaflet	Aphid Population	Yield Per Acre
		No.	No.	Class 1/	Bu.
1951					
DDT	1-100	0	19.3	4	560
Methoxychlor	2-100	0	16.0	5	520
Parathion	1-100	0	20.8	1	614
Malathion	2-100	0	21.9	1	568
EPN	1-100	0	24.6	3	538
Dilan	1-100	0	17.2	3	560
Pestox 3	1.5-100	3.6	26.7	1	560
Systox	1.5-100	0.1	18.6	1	580
Untreated Check		4.0	23.5	3	506
1952					
Methoxychlor	2-100	0	16	5	486
Malathion W.P.	2-100	0	25	1	507
Malathion Em. C.	1-100	0	21	1	539
Parathion	1-100	0	19	1	501
Dieldrin	2-100	2.3	4	4	536
Systox	1.5-100	0	13	1	609
Untreated Check		3.7	27	3	352
1953					
Systox	1-100	0	30	1	416
Strobane	3-100	0.3	18	4	516
Compound 4389	2-100	.4	26	2	530
Parathion	1.5-100	.3	29	1	556
Endrin 18	1-100	.4	21	2	611
Dieldrin	1-100	1.6	10	4	488
Malathion	2-100	.6	27	1	530
Malathion + Perthane	2-1.5-100	0	30	1	497
Methoxychlor	2-100	0	19	5	518
Untreated Check		3.8	30	3	300
1954					
Systox	1-100	0	25	1	453
Chlorthion	3-100	0	34	1	399
Malathion	3-100	0	28	1	363
Compound 12008	1-100	0	21	1	414
Compound OS 2046	0.5-100	0	25	1	352
Endrin	1.5-100	1.0	16	3	402
Dieldrin	1-100	2.1	5	3	429
Diazinon	2-100	.4	29	1	408
Malathion + Methoxychlor	3-3-100	0	6	2	414
Compound 12009	1-100	0	25	2	263
Untreated Check		7.2	55	3	374

1/ Classes of aphid populations: 1= none; 2 = trace; 3 = light; 4 = medium; 5 = heavy.

Table 73. Yield and defoliation data relative to the performance of a series of fungicide - insecticide formulations applied to potatoes at three locations (Marietta, Wooster and Willard) in 1955.

Treatments*	Formulas	Yields in Bu/Acre at			Percent Foliage Dead at			Averages	
		Mari-etta	Wooster	Wil-lard	Mari-etta	Wooster	Wil-lard	Yield	Percent Foliage Dead
1. Bordeaux	4-2-1-100	600	603	515	62	55	48	573	55
2. " + K704	4-2-1/2-1-100	584	569	495	65	61	51	549	59
3. " + X-100	4-2-1/4-1-100	613	593	527	62	57	51	578	57
4. " + K704 + X-100	4-2-1/2-1/4-1-100	626	626	516	56	47	50	589	51
5. " + Tribasic	2-1-3-1-100	609	597	520	56	50	43	575	50
6. Tribasic	4-1-100	594	563	518	59	49	42	558	50
7. " + K704	4-1/2-1-100	609	584	527	52	41	45	573	49
8. Cop-O-Zinc	4-1-100	606	637	507	57	40	43	583	47
9. Tennam	3-1-100	598	626	525	64	44	35	583	48
10. Captan	3-1-100	602	620	528	67	52	42	583	54
11. Dithane D-14 + $ZnSO_4$	4-1-1-100	623	677	542	44	32	33	614	36
12. " + $MnSO_4$	4-1-1-100	606	637	539	57	42	37	594	45
13. " + $CuSO_4$	4-1-1-100	628	653	527	56	37	37	603	40
14. Dithane M-22	2-1-100	635	611	538	57	49	45	595	50
15. Dithane M-22 + endrin (25% W.P.)	2-1-100	556	627	552	51	44	32	578	46
16. " " + heptachlor (25% W.P.)	2-1-100	607	605	550	57	55	36	587	49
17. Dithane M-22 + methoxychlor (25% S.P.)	2-1-100	581	583	558	59	49	35	574	48
18. " " + Systox (50% Emul.)	2-1-100	630	656	541	48	46	34	609	43
19. " " + parathion (15%) + dieldrin (50%)	2-1-1/2-100	653	614	548	53	46	37	605	45
20. No treatment		568	574	479	85	64	64	540	74
L.S.D. at 5% level		48	39	18					

*D-d used with all treatments, except as indicated, at 1-100.

Table 74. The effect of varying the pressure-volume (droplet-size) combinations of spray application on disease control and yield of Cobbler potatoes at Wooster in 1955.

Treatment*	Concen- tration "X"	Gallons per acre	Pressure P.S.I.	Tractor speed M.P.H.	Nozzle Number	Yield Bu/Acre	Percent Foliage Dead
1.	4.6	35	40	1.1	9502	526	52
2.	4.6	35	40	2.1	9504	545	54
3.	4.6	35	40	3.7	9508	508	56
4.	4.6	35	40	1.3'	D4,C25	550	50
5.	4.6	35	40	3.7	D10,C25	537	50
6.	4.6	35	30	1.4	9503	519	54
7.	4.6	35	70	2.1	9503	568	51
8.	4.6	35	250	4.0	9503	559	51
9.	16.0	10	40	2.4	95015	534	60
10.	8.0	20	40	1.9	9502	534	54
11.	2.7	60	40	3.1	9510	573	52
12.	2.0	80	40	2.3	9510	556	55
13.						498	64
L.S.D. at 5% level						42	

*Dithane M-22 + D-d used on all plots.

Table 75. The influence of various adjuvants on the disease control effectiveness of Tribasic on Russet potatoes at Wooster in 1955. Three tank-mix dithiocarbamates are also included in the list of treatments. Both early and late blights of medium severity.

Treatments	Formulas	Yield Bu/Acre	Percent Foliage Dead on Sept. 11	Oct. 3
1. Tribasic + D-d	4-1-100	352	27	72
2. " + K704 + D-d	4-1/2-1-100	382	26	65
3. " + X-100 + D-d	4-1/4-1-100	356	26	58
4. " + K704 + X-100 + D-d	4-1/2-1/4-1-100	366	27	65
5. " + X-104 + D-d	4-1/4-1-100	341	29	70
6. " + X-411 + D-d	4-1/4-1-100	375	24	58
7. " + Veg. Oil + D-d	4-1-1-100	388	20	61
8. Dithane D-14 + $ZnSO_4$ + D-d	4-1-1-100	401	29	60
9. B-Nabam + $ZnSO_4$ + D-d	4-1-1-100	347	31	62
10. SDD + $ZnSO_4$ + D-d	2-1-1-100	335	41	72
11. Tribasic + parathion	4-1-100	422	25	50
12. No Treatment		256	84	100

Table 76. Data relative to disease and insect control, and yield on Cobbler potatoes, grown on Osborne Welfare Farm at Sandusky in 1955 when sprayed with airplane and airblast equipment. Diseases and insects were scarce. Zineb + D-d used on all treated plots.

	Yield Bu/A	Average Micrograms Of copper Recovered Per sq. cm. Of Leaf surface	Percent Foliage Dead Aug.	Number Flea beetle Punctures Per leaflet July 8	Leafhopper Nymphs per Leaf July 8	Aphids Per leaf July 8
Air-blast						
No treatment	344		60	107.5	1.3	28.5
20 gal/acre	370	33.2	36	0.13	0	0
30 gal/acre	348	24.8	35	0	0	0
40 gal/acre	341	27.1	33	0	0	0
Airplane						
No treatment	344		60	107.5	1.3	28.5
5 gal/acre	360	19.5	36	0	0	0
10 gal/acre	366	23.0	32	0	0	0
15 gal/acre	388	28.4	30	0	0	0