The yields for 1947 generally compared with the results in 1946. DDT 3% dusts again yielded more than DDT 5% dusts although only 1.7 bushels per acre as compared to 28 bushels for 1946.

The combination DDD 3% and HE 761 2% dusts was highly significant at the 1% level and the highest yielding plot. This combination was not available in 1946 when DDD alone gave significant results at the 5% level. In the 1947 plots DDD was third highest in tuber yield and lacked but 1.1 bushels in yield to attain significant yield at the 5% level.

Appreciation is expressed to the Agricultural Supply Company of Grand Forks, North Dakota and the Rohm and Haas Company, Philadelphia, Pennsylvania for grants in support of the insect investigations reported herein.

POTATO FUNGICIDE EXPERIMENTS IN 1947 [1]

By

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Experiments with potato fungicides were started in 1945 to determine the effectiveness of some of the newer materials for controlling the fungi, *Alternaria solani* and *Phytophthora infestans*, causing respectively early and late blights of potatoes. Attention was also given to the time and frequency of application and the effect of the various treatments on yield. The results obtained in 1945 (2) indicated Dithane D-14 and Zerlate were very effective for controlling early blight. This disease was not present on the plots during 1946 and late blight has never been observed during the course of this work. A few new fungicides and the most promising of those used in 1945 were included among those tested in 1947.

Certified Bliss Triumph seed was cut and treated May 12, 1947. The treatment consisted of a 5-minute dip in a solution containing 6 ounces of mercuric chloride, 1 quart of commercial hydrochloric acid and 25 gallons of water. An assisted feed planter was used to plant the 3½-acre plot May 14 and 15 on land donated by the Flaat Farms Company and located approximately 3½ miles south of Grand Forks, North Dakota, on Washington avenue. The soil at this particular location was Bearden silt loam. A triple lattice design was used for arranging the 16 different treatments. Each treatment was replicated 6 times and each of the 96 plots was 2 rows wide and 80 feet long with 2 untreated rows on each side.

The dusts were applied with a 2-row, tractor-mounted, Niagara duster having 3 nozzles to the row. A 2-row, power-take-off, Bean sprayer, having 3 nozzles to the row was used for applying the sprays at a pressure of 350 pounds. In order to minimize the

[1]Commercial cooperators included the Agricultural Supply Company, Grand Forks, N. Dak., Tennessee Copper Company, Rohm and Haas Company, E. I. du Pont de Nemours and Company, United States Rubber Company and Harshaw Chemical Company.

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amount of drift, the materials were applied during the evenings or early mornings except on days when there was little, if any, breeze.

Due to an infestation of the potato flea beetle, *Epitrix cucumeris,* and the Colorado potato beetle, *Leptinotarsa decemlineata,* all the plots except the check received 5 per cent DDT dust on July 2 at the rate of 20 pounds per acre. Applications of fungicides were made July 15 and 31, August 9, 19 and 27, and September 3. The first 3 applications of fungicide-containing dusts were applied at 20 pounds per acre. After a trace of early blight was noticed August 19, the rate was increased to 30 pounds. The first 3 applications of spray materials were applied at 100 gallons per acre; this amount was increased to 150 gallons beginning August 19. Plot 1D was dusted with 5 per cent DDT and plot 2D received the same insecticide until August 19 when the treatment was changed to the Zerlate and DDT spray being applied on plot 11S. Plot 7S had the same treatment as 8S except Dithane was omitted from the former. Since wheel injury causes a decrease in yield, the tractor and attached sprayer were driven over the check plots each time the applications were made.

The early-blight readings were taken September 18 or 15 days after the last application of fungicides. To determine the amount of disease, a scale was used in which 1=trace, 2=very slight, 3=slight, 4=moderate, 5=severe and 6=very severe infection. A moderate to severe spread of the disease occurred on the check plots this year.

In addition to the potato flea beetle and Colorado potato beetle, the potato leafhopper, *Empoasca fabae,* and the 6-spotted leafhopper, *Macrosteles divisus,* were observed during the summer. The light insect infestation was partially attributed to the use of DDT with all the fungicides.

The growing season at Grand Forks in 1947 was ideal with respect to potato production and the yields given in table 1 are further evidence of this fact.

The early-blight readings (Table 1) indicated that spraying with Dithane D-14 or Zerlate gave the best control. Equally effective was the treatment received by plot 2D. It had 4 dustings of 5 per cent DDT until August 19 and then 3 applications of Zerlate and DDT spray during the remainder of the season. From this year's results it was apparent that 3 applications of Zerlate spray applied at weekly intervals following the appearance of early blight were just as effective as 6 applications during the entire season.

Plot 7S had the same treatment as 8S except the Dithane D-14 was omitted from the former. There was very little difference in the amount of early blight as indicated by the total scores of the respective replications. Further evidence was obtained on some supplementary plots sprayed with a zinc-copper mixture, the

results of which are not included in this paper, that early-blight infection was less on potatoes receiving zinc in the spray material. In this case the amount of disease was the same as that on plot 7S.

Two new materials, Dithane Z-78 and Parzate, are somewhat similar chemically but differed considerably with respect to controlling early blight. The former ranked seventh while Parzate was second.

Zerlate, Dithane Z-78 and unmicronized Tribasic Copper Sulphate were each applied as dusts and sprays, and in each in-

Table 1.—The effect of the treatments on early-blight control and yields, and the cost of the materials per acre.

Plot	Treatment	Total early-blight score, 6 replications	Rank according to least early blight	Total yield, bushels per acre	Cost of insecticides and fungicides per acre[3]
1D[1]	5% DDT	25.25	11	267.4	$15.72
2D	5%DDT until Aug. 19 and then Zerlate and DDT. 2-1-100[2]	20.00	1	259.4	17.93
3D	6% Dithane Z-78 and 5% DDT	24.25	9	270.0	25.10
4D	10% Zerlate and 5% DDT	23.00	7	305.0	25.10
5D	7% Unmicronized Tribasic Copper Sulphate and 5% DDT	24.50	10	259.7	20.22
6D	6% Copper A Compound and 5% DDT	25.50	12	262.9	20.22
7S[1]	Zinc Sulphate, Lime and DDT. 1½-½-1-100	21.00	3	270.4	11.61
8S	Dithane D-14, Zinc Sulphate, Lime and DDT. 2 qts. 1½-½-1-100	20.00	1	288.9	20.61
9S	Dithane Z-78 and DDT. 2-1-100	23.00	7	275.3	27.35
10S	Parzate and DDT. 2-1-100	20.75	2	279.0	27.35
11S	Zerlate and DDT. 2-1-100	20.00	1	284.1	19.40
12S	Phygon and DDT. 1-1-100	22.75	6	272.2	23.97
13S	Unmicronized Tribasic Copper Sulphate and DDT. 4-1-100	22.50	5	269.0	17.30
14S	Copper Oxychloride Sulphate and DDT. 4-1-100	24.00	8	273.0	17.20
15S	Bordeaux Mixture and DDT. 8-8-1-100	22.00	4	269.0	21.50
16	No treatment	27.00	13	257.3	

Least significant difference at 5 per cent level equalled 24.52 bushels and 32.61 bushels at the 1 per cent level.

[1]D following a plot number refers to dust and S to spray.
[2]All spray materials are expressed in standard units of weight or liquid measure sufficien to make 100 gallons of spray mixture. For example, Zerlate and DDT 2-1-100 mean 2 pounds of Zerlate and 1 pound of DDT with sufficient water to make 100 gallons o spray mixture.
[3]Based on 1947 prices.

stance the sprays were more effective. This was particularly true of Zerlate.

Fungicides containing copper have been used extensively on potatoes since the discovery of Bordeaux mixture. Of the copper-containing fungicides applied this year, Bordeaux mixture was the most effective for controlling early blight while Copper A Compound was no better than 5 per cent DDT.

The total yields in table 1 indicate plots 8S and 11S, sprayed with Dithane D-14 and Zerlate respectively, had yields greater than the check at the 5 per cent level of significance. These 2 plots, and plot 2D, each ranked first with respect to the least amount of early blight, but the yield of the latter was approximately the same as the check. A moderate infection of early blight occurred on plot 4D but it had a highly significant total yield of 305 bushels per acre. These results show a negative correlation does not always exist between total yield and early-blight score, and indicate another factor or factors may be influencing the yield. Plots 2D and 11S each ranked first with respect to early-blight control but a significant difference of 24.7 bushels existed between their total yields in favor of the latter. Plot 11S had 6 applications of Zerlate spray while 2D received 3 treatments beginning August 19. Both plots had equal amounts of DDT throughout the season. During the dry season of 1946 (1), when early and late blights were absent, the highest yields were obtained on plots sprayed with zinc-containing fungicides.

According to some growers and dealers, fungicides containing copper "stimulate" the plants and increase the yield. During 1946 (1), when no fungus diseases were present on the leaves, there was no apparent increase in yield from the use of 3 copper-containing fungicides on plots located at Grafton, North Dakota. Four different plots received copper fungicides this year and all except 14S yielded less than 270 bushels per acre.

The retail prices of the various products, with the exception of Parzate, were supplied by the Agricultural Supply Company of Grand Forks. The per acre costs varied from $11.61 for plot 7S to $27.35 for plots 9S and 10S.

Summary

1. Sixteen different treatments were applied to Bliss Triumph potatoes at Grand Forks, North Dakota, to determine which were the most effective for controlling *Alternaria solani* and *Phytophthora infestans*, the fungi causing respectively early and late blights, and their effect on yields.

2. Early blight was first observed on the lower leaves August 19 and became moderate to severe on the check plots at the time the early-blight readings were taken September 18. Late blight was never observed on the foliage.

3. The Colorado potato beetle, *Leptinotarsa decemlineata*, the potato flea beetle, *Epitrix cucumeris*, the potato leafhopper,

Empoasca fabae and the 6-spotted leafhopper, *Macrosteles divisus* were present at various times throughout the season. The slight insect infestation was partially attributed to the use of DDT on all but the check plots.

4. Dithane D-14 and Zerlate sprays were the most effective for controlling early blight followed by the spray materials Parzate, zinc sulphate and lime, and Bordeaux mixture in that order.
5. Three applications of Zerlate spray on plot 2D, at weekly intervals following the appearance of early blight, were just as effective as 6 applications (Plot 11S) during the entire season, but the yield of plot 11S was significantly greater than 2D.
6. The omission of Dithane D-14 (Plot 7S) from the regular Dithane D-14, zinc sulphate and lime treatment (Plot 8S) resulted in only an appreciable increase in the amount of early blight.
7. Parzate was superior to Dithane Z-78 as a fungicide for early blight.
8. Zerlate, Dithane Z-78 and unmicronized Tribasic Copper Sulphate were each applied as dusts and sprays and in each instance the sprayed plots had less disease.
9. A highly significant total yield of 305 bushels per acre occurred on the Zerlate-dusted plot 4D even though it ranked seventh with respect to the least amount of early blight.
10. Plots 8S and 11S, sprayed with Dithane D-14 and Zerlate, had significant total yields of 288 and 284 bushels per acre.
11. Of the 9 treatments yielding 270 bushels or more per acre, all but 2 received zinc-containing fungicides.
12. If total yield may be taken as the criterion, there was no evidence to indicate copper "stimulated" the plants and increased the yield.

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