# SEEDLING DISEASES OF SUGAR BEETS

Thesis for Degree of M. S.

Dewey Stewart

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THESIS

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## Introduction.

The sugar beet industry is a very important phase of Michigan agriculture. In 1923, 96,000 acres were planted to this crop which returned to the farmers an average of $72.00 per acre. In general, the area devoted to sugar beet culture is the central part of the Lower Peninsula. The soil type, for the most part, is sandy loam, however some contain a large amount of humus and, in some localities, muck soil is used. The areas planted to beets are commonly bottom or low valley lands, where tile drainage is necessary in order that agriculture may be practiced.

Beets are commonly grown in a four-year rotation as the agriculturists connected with the industry strongly advise against following beets with beets. In many sections it is planned to have beets follow clover, but in recent years beets have been used most successfully following cultivated crops.

The crop is planted over a period ranging from very early spring (April 20th) to late spring (June 20th). Seed is sown very heavily in drills 24 inches apart and the young plants are cultivated frequently as soon as they can be seen in the rows. The plants are allowed to grow with no attempt at thinning until a decision can be made as to the stand. If soil and weather conditions have been favorable and cultivation timely a stand profitable to work generally results. If, on the other hand, intensive rains, low temperature, or poor seed factors enter, the stand is poor. In such cases the field is dragged up and either replanted to beets or some other crop. Some years as much as 25 percent of the acreage planted in some

sections fails to show a profitable stand and must be replanted to beets or to some other crop. It is obvious that the matter of a good stand is fundamental to successful sugar beet raising.

The common cause of failure to get a stand is fungous attack which gives rise to the so-called "seedling diseases" of sugar beets. A general discussion of the nature of these diseases and their importance under Michigan conditions has been given by Coons (3). In this article, the suggestion for some form of seed treatment as a means of control is made. This investigation has consisted in tests with sugar beet "seed" under laboratory and greenhouse conditions in an attempt to evaluate the various types of seed treatment which have been suggested.

## Previous work on Seedling Diseases of Sugar Beets.

The early American experiments to show that the death of sugar beet seedlings was caused by pathogenic organisms were conducted by Duggar and Stewart (5) in 1901. Their investigation proved that Corticium vagum B. & C. var. solani Burt. (called by them Rhizoctonia) was capable of killing sugar beet seedlings. Duggar (4) in New York, Pammel (9) of Iowa, and Selby (15) of Ohio had previously reported Rhizoctonia as causing a root rot in fields of mature beets.

European literature for many years had contained more or less extensive studies on sugar beet diseases. In a series of reports between 1906 and 1911 Peters (10, 11, 12) and his co-workers (1, 2) went over this literature and from this and their own experiments concluded that Pythium debaryanum Hesse,

Phoma betae Fr. and Aphanomyces laevis DeBy. are the organisms concerned in the production of seedling diseases of sugar beets in Germany. They were unable to produce damping-off with Rhizoctonia violacea Tul. In 1915 Edson (6), working at Madison, Wisconsin, found Phoma betae, Pythium debaryanum and Rhizoctonia spp., as well as an organism which he later named Rheosporangium aphanidermatum Edson (7) as the principal organisms concerned in the seedling diseases of sugar beets. Each organism produced a high percentage of diseased plants when introduced into the seed bed. Edson also found Phoma present on all lots of seed balls examined from America and Europe, thus confirming previous results of Peters.

Although Phoma is constantly being introduced into sugar beet fields, Pool and McKay (13) have shown that it does not live from year to year in the soil unless on fragments of sugar beets. However, Rhizoctonia and the Phycomycetes, Pythium debaryanum, Aphanomyces laevis and Rheosporangium aphanidermatum are common soil organisms as shown by Jensen (8).

The problem of controlling sugar beet seedling diseases was, therefore, concerned with the seed-borne fungus, Phoma and the numerous soil-inhabiting fungi. It is obvious that unless uninfested soil is available for use with disinfected seed, treatment of seed will, at most, be only partially effective. Besides this difficulty, it was found that treatment of seed balls so as to eliminate Phoma betae as a factor was almost impossible. Edson (6) in trying to find some means of freeing his inoculation experiments of Phoma tried strong solutions of hydrochloric acid, concentrated sulphuric acid for one hour,

and 2% formalin solution for periods sufficient to injure the seedlings without materially reducing the presence of Phoma. However, Peters' method of pasteurization at 60°C. for 10 minutes on two successive days gave one Phoma-diseased plant in about four hundred. Edson states that this method is not practical for field use as the germination is reduced.

In 1924 Miss Rumbold (14) reported favorable results in sugar beet seed disinfection using formaldehyde and steam. This method has not as yet come into general use.

## Symptoms.

The diseases of sugar beet (Beta vulgaris L.) seedlings considered in this investigation are those commonly known as "Black root", "Root sickness" and "Damping-off". No distinction can be made between these various names since they are used loosely to apply to death of seedlings from one cause or another.

The common signs of this type of disease are a blackening of the hypocotyl and root. The discoloration usually shows above the surface of the ground before the seedling topples over. This killing may be fairly rapid or take place so slowly that the seedling seems to almost outgrow the disease. The plants show great persistence as frequently a plant is seen entirely blackened as far as the cotyledons, which, however, may be turgid and green. Examination of such seedlings shows the vascular region as the only part not decayed. Another type of attack which is very common is a distinct wilting of the seedling. On removing such plants a brown, decayed region is found on the root. The central vascular region is discolored brown in advance of the external lesion. These lesions have

a water soaked appearance as compared with the dry, black appearance of the other type of attack. Twenty four hours after the first indications of wilting the seedling is found to be almost completely decayed. A seedling has never been observed to recover after the onset of this type of disease. Another type of seedling disease not so distinctive in appearance as the others is the discoloration of the young leaves. In such cases, seedlings make a slow growth and, in general, show evidence of malnutrition. On removing the seedling the tap root is found decayed at the tip and the rootlets above the decayed region are functioning and apparently attempting to replace the primary root. No doubt many of these seedlings would mature beets, but they would be of poor type.

A Survey of the Vicinity of Lansing, Michigan.

Samples of sugar beet seed were secured from Mr. E. E. Down of the U. S. Department of Agriculture. These samples were from his isolated breeding plots in the vicinity of Lansing. These seeds were hand cleaned and in general handled as carefully as a person would handle seed from breeding plots. This, in addition to the fact that they were isolated, should have given almost a Phoma-free seed.

Samples of 50 seed balls were planted in sterile sand in a moist chamber. As the seedlings began to die they were examined for Phoma. Phoma was determined by the characteristic worm-like coil of spores from a pycnidium when placed in water on a microscope slide. Fifteen samples from different localities were used. Phoma betae was found in 10 samples

of the 15 representing all directions from Lansing and the College Farm. Two samples were from farms where poor stands due to disease were known to have occurred, and each sample showed Phoma in great amounts. No doubt if a diligent search had been made or new samples planted, Phoma betae could have been found in all lots.

## Preliminary Experiments in Laboratory.

The first work undertaken consisted in studies to determine the best methods of experimentation. The nature of the problem can be seen by the following brief test in the laboratory.

The seed balls were treated with various disinfectants applied both as liquids and dusts. Moist chambers (15 cm. in diameter x 6-8 cm. high) were sterilized and the treated balls placed between moist absorbent paper. Seedlings germinated in this way soon became covered with Alternaria and Mucor. Also in this method certain chemicals such as mercury bichloride leached from the seed balls showed a harmful effect on the roots.

Tests were made in these same moist chambers using clean, sterile quartz as a seed beed. In this case the seedlings seemed to die in a few days after germination regardless of the treatment. This was thought to be due to the excessively moist atmosphere of the chamber.

Battery jars 25-30 cm. high covered with halves of moist chambers were substituted for the moist chambers, and sterile quartz used as before. This way the seedlings grew for many days in apparently normal condition. The mercury treatments

which had shown injurious effect between moist paper now gave the best germination and fewest diseased seedlings over a period of 12 days. Examination of diseased seedlings from treated and untreated jars showed Phoma betae to be generally present in both. These treatments were made with mercury compounds, formalin and formaldehyde compounds, copper compounds, and furfurol, about 15 in all.

These experiments made it evident that complete disinfection of seed balls was hardly to be obtained with the chemicals used. The small germinator type of experiment was taken to be of doubtful value for the purpose of the investigation. Accordingly, attempts were made to grow beets under conditions approximating those in the field.

## Experiments in Greenhouse.

### Experiment #1 - On muck soil.

The preliminary experiments in the laboratory had indicated that a partial control for Phoma betae and other fungi could be expected with certain chemical treatments. Tests with soil were chosen because experiments conducted in this manner gave an opportunity to determine the value of the various treatments as a preventive against organisms arising from the soil as well seed-borne ones. In these experiments the seed balls were sown in soil and given careful attention. The bed used was 34" wide and 6" deep. The rows were 3" apart and had 50 seed balls per row planted 1" deep. Every third row was a check. The "seed" was American-grown, secured from the Holland-St. Louis Sugar Company. The diseased seedlings were removed after records taken. The records were taken at intervals of 2-3 days over

a period of 23 days, beginning with germination. Each treatment was in duplicate one half the length of the bed apart.

Table I.

| Treatment. | No. of seedlings. | | No. diseased seedlings. | | Percent disease. |
|---|---|---|---|---|---|
| | Per row. | Total | Per row. | Total. | |
| 1. Chlorophol | 121 | | 19 | | |
| " | 113 | 234 | 17 | 36 | 15 |
| 2. Pythal | 96 | | 15 | | |
| " | 98 | 194 | 10 | 25 | 13 |
| 3. $HgCl_2$ 1-1000 | 93 | | 10 | | |
| " | 93 | 186 | 24 | 34 | 18 |
| 4. "620" | 88 | | 11 | | |
| " | 90 | 178 | 13 | 24 | 14 |
| 5. $CuSO_4$ +lime | 112 | | 29 | | |
| " | 112 | 224 | 21 | 50 | 22 |
| 6. $CuCO_3$ (Corona) | 93 | | 18 | | |
| " | 91 | 184 | 23 | 41 | 22 |
| 7. $CuCO_3$(Dow) | 99 | | 44 | | |
| " | 89 | 188 | 6 | 50 | 27 |
| 8. Seed-O-San | 72 | | 33 | | |
| " | 107 | 179 | 68 | 101 | 56 |
| 9. Kalimat | 75 | | 43 | | |
| " | 84 | 159 | 45 | 88 | 56 |
| 10. Formalin 1-240 | 55 | | 28 | | |
| " | 46 | 101 | 29 | 57 | 56 |
| 11. Check (Av. 18 rows) | 60 | | 24 | | |
| " | 60 | 120 | 24 | 48 | 40 |
| 12. $NiCO_3$ | 73 | | 58 | | |
| " | 83 | 156 | 59 | 117 | 75 |
| 13. Furfurol 3% | 57 | | 33 | | |
| " | 69 | 126 | 14 | 47 | 38 |
| 14. Furfurol 2% | 42 | | 9 | | |
| " | 53 | 95 | 12 | 22 | 22 |
| 15. Furfurol 1% | 75 | | 25 | | |
| " | 72 | 147 | 25 | 50 | 34 |

Table continued on next page.

Table I continued.

| Treatment. | No. of seedlings. | | No. diseased seedlings. | | Percent disease. |
|---|---|---|---|---|---|
| | Per row. | Total. | Per row. | Total. | |
| 16. Lime | 73 | | 9 | | |
| " | 87 | 160 | 13 | 22 | 14 |
| 17. Large seed balls | 68 | | 20 | | |
| " | 75 | 143 | 10 | 30 | 21 |
| 18. Small seed balls | 24 | | 5 | | |
| " | 29 | 53 | 0 | 5 | 10 |

Explanation of treatments in Table I.

1. Chlorophol is an organic mercury compound used at the rate of 1 gr. per gallon of water for 1 hour.

2. Pythal is an organic mercury compound sold by the Chicago Process Company, Chicago, applied in 1/4% solution for 1 hour.

3. $HgCl_2$ 1-1000 - treated an hour.

4. "620" is an organic mercury compound applied for one hour. Furnished by Corona Chemical Co., Milwaukee, Wis.

5. $CuSO_4$ + lime was a mixture consisting of equal parts dehydrated $CuSO_4$ and dehydrated lime.

6. $CuCO_3$ (Corona) furnished by Corona Chemical Co., Milwaukee, Wis.

7. $CuCO_3$ (Dow) furnished by Dow Chemical Co., Midland, Mich.

8. Seed-O-San is an organic mercury compound applied in excess, in dust form.

9. Kalimat, a Formaldehyde compound furnished by Chicago Process Co., Chicago, Ill.

10. Formalin 1-240 applied for 30 minutes.

11. Untreated, American-grown seed.

12. Nickel carbonate dust in excess.

13. Furfurol 3% applied for one hour in all concentrations.

14. Furfurol 2% " " " "

15. Furfurol 1% " " " "

16. Lime-Hydrated lime applied in excess.

17. Large seed balls were secured by sifting the commercial seed through a screen 36 meshes per inch. The seed balls remaining in the screen were considered large.

18. Small seed balls,- those seeds which sifted through above mentioned screen were considered small.

Discussion of Table I.

Bichloride of mercury, Pythal, Chlorophol and "620" all show great reduction in disease with high total germination. This shows a superiority of mercury and mercury compounds as a treatment.

The copper dust treatments gave an increase in germination and a decrease in percentage of diseased seedlings. The "Dow" carbonate gave a poorer stand than the "Corona" although it has a higher percentage of copper. It is not ground very fine and this will probably explain its performance. Copper compounds in the form of a dust show promise as a means of control as well as mercury compounds.

Formalin, Kalimat and Seed-O-San are of no value in preventing seedling diseases after plants have emerged from the soil.

Nickel carbonate showed an injurious effect and Furfurol in general, for the concentrations used, was of no value. The effect of lime was somewhat unexpected. The germination was about that of the check but the disease, after the plants emerged, was reduced.

It was thought possible to eliminate the greater part of the Phoma by discarding the small seed balls. The preliminary experiments in the laboratory had shown Phoma betae on the larger seed balls, as well as the small ones, and this indicates about what would be expected from seed balls so separated as far as total germination and percent of disease are concerned if Phoma was present on neither.

## Technique.

The method of planting was changed for Experiment 12, to insure uniformity as far as far as space and depth of seed were concerned and followed for all future bed experiments in the greenhouse. A lath containing 30 holes 1 inch apart was placed across the bed, leaving a 4-inch margin on the back and 2-inch margin on the front. Thirty holes were made in the soil through the lath. A seed ball was placed in each hole and forced one inch below the surface. The rows were exactly 3 inches apart. All seed in future work was from the same sack as used in Experiment 11. An average sized lot of 30 balls was counted out in each case before they were planted to insure an average number of seeds per row so far as possible.

A definite record as to date and row number was kept for each diseased seedling and the corresponding date was recorded

for the organism found with it. Each diseased seedling was treated with $HgCl_2$ 1-1000 for 1-2 minutes and rinsed in sterile water before plating on cornmeal agar.

In determining the organism part of the growth was examined under the microscope. No distinction was made between Pythium and its close relatives. All were called Pythium.

Experiment #2 - On muck soil.

In the first experiment no attempt was made to determine the organism associated with the diseased seedlings. This experiment is similar in all respects except for technique and organism determination. These data represent records taken at intervals of 2-3 days over a period of 19 days after the seedlings appeared.

Table II.

| Treatment. | No. seedlings. | | No. diseased seedlings. | | % disease. | Organism. |
|---|---|---|---|---|---|---|
| | Per row | Total | Per row | Total | | |
| *Semesan | 57 | | 4 | | | Pythium |
| " | 53 | 112 | 4 | 8 | 7 | Bacteria |
| $CuCO_3$ (Corona) | 53 | | 18 | | | Bacteria |
| " | 54 | 107 | 7 | 25 | 23 | Pythium |
| $CuCO_3$ (Dow) | 44 | | 14 | | | Pythium |
| " | 41 | 85 | 18 | 32 | 38 | Pythium |
| $CuSO_4$+lime | 41 | | 9 | | | Pythium |
| " | 39 | 80 | 15 | 24 | 30 | Alternaria |
| Furfurol 3% | 35 | | 14 | | | Pythium |
| " | 38 | 73 | 10 | 24 | 33 | Pythium |
| Furfurol 1% | 30 | | 11 | | | Pythium |
| " | 27 | 57 | 15 | 26 | 47 | Ascomycete |
| Large seed balls | 54 | | 22 | | | Pythium |
| " | 38 | 92 | 15 | 37 | 40 | Pythium |
| Small seed balls | 18 | | 3 | | | Pythium |
| " | 14 | 32 | 3 | 6 | 19 | Bacteria |
| Large seed balls & lime | 29 | | 10 | | | Aspergillus |
| " | 30 | 59 | 9 | 19 | 32 | Cephalothecium |
| Small seed balls & lime | 17 | | 2 | | | No growth. |
| " | 15 | 32 | 3 | 5 | 16 | Bacterium |
| Check (Av. 13 rows.) | 27 | | 10 | | | 6 Pythium |
| " | 27 | 54 | 10 | 20 | 38 | 1 Rosellina |
| | | | | | | 3 Fusarium |
| | | | | | | 2 Aspergillus |

*All treatments same as in Table I, except Semesan which is an organic mercury compound furnished by the E. I. duPont de Nemours Co. It was applied in dust form.

## Discussion of Table II.

A new mercury compound, Semesan, was introduced which gave promising results both in the total germination and the percentage of diseased seedlings found. This is a powder and can be used either as a liquid or as a dust treatment. In this case, the dust application was used.

The copper compounds were as good as before, however, the faults of the "Dow" preparation were magnified. "Corona" copper carbonate was used entirely in future tests.

The two concentrations of Furfurol used showed no control and were eliminated from future tests.

The separation of the seed balls gave no indication of a means of control. Although lime appeared very good before it proved worthless when applied to small and large seed balls. Lime, except with copper sulphate, was also eliminated from future tests.

Formalin and formaldehyde compounds were not used because they had proved to be very poor and the mercury compounds were not repeated as they would be given further test later.

The seedlings examined showed a large majority of Pythium cultures. It is interesting to note that not a single culture of Phoma or Rhizoctonia was found. Why Phoma was not found can not be explained since it was so common in this lot of seeds.

Experiment #3.-On sandy loam.

To see if the type of soil was responsible for the common occurrence of Pythium, and also to compare types of soil, a change of soil was made from muck to sandy loam. This soil was from the College Farm and had grown a crop of beans the year before. No record of it ever having sugar beets on it can be found. In conformity to general practice among seed analysts, a standard of two seedlings per seed ball has been set up in the following tables as a sort of normal or "ideal" germination which might be expected from such seed if the disease factor did not enter. In the tables that follow, it will be noted that two cases were found where this standard number was slightly exceeded. Seed balls in sterile sand and also those in sterile soil when given the most effective of the seed treatments averaged about 1000 seedlings from 500 seed balls.

Based upon this number a column showing the percentage of seedlings emerging (commonly called germination) above the surface of the soil is given. Also the percentage of stand of apparently healthy seedlings after the last count was made, is similarly computed.

The column of percent diseased is the actual percentage of disease among those appearing above the surface of the soil.

In the other experiments it was found that records taken every two or three days would not account for all the seedlings

or some could not be accounted for. The slight variation in numbers from day to day is in part due to this loss of individuals, and the same variation arises from delayed germination of the seed balls. Close observation showed that rapid killing and decay of the seedlings took place. This type of disease has already been described under symptoms. During this experiment records were taken every afternoon for thirteen days, starting immediately after germination.

Table III.

| Treatment | No. diseased seedlings. | | | Healthy seedlings at end of exp't. | | | Total no. seedlings emerging. | | | Organism. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Per row. | Total | % | Per row | Total | % | Per row. | Total | % | |
| 1.Semesan | 15 | | | 57 | | | 72 | | | 1 Mucor |
| " | 9 | 24 | 18 | 53 | 110 | 92 | 62 | 134 | 112 | 1 Pythium |
| | | | | | | | | | | 1 Rhizoctonia |
| | | | | | | | | | | 1 Mucor & Fus. |
| 2.Uspulun | 10 | | | 53 | | | 63 | | | 1 Mucor |
| " | 14 | 24 | 19 | 50 | 103 | 82 | 64 | 127 | 106 | 1 Phoma |
| | | | | | | | | | | 3 Pythium |
| 3.$HgCl_2$ | 6 | | | 33 | | | 39 | | | None. |
| " | 4 | 10 | 11 | 49 | 82 | 68 | 53 | 92 | 77 | 1 Pythium |
| 4.DuPont #13 | 7 | | | 34 | | | 41 | | | 1 Rhizoctonia |
| " | 2 | 9 | 10 | 47 | 81 | 66 | 49 | 90 | 75 | 2 Pythium |
| | | | | | | | | | | 2 Mucor |
| 5.Pythal | 3 | | | 36 | | | 39 | | | None |
| " | 16 | 19 | 21 | 37 | 73 | 60 | 53 | 92 | 76 | 1 Pythium |
| | | | | | | | | | | 2 Mucor |
| | | | | | | | | | | 1 Fusarium |
| 6.Chlorophol | 8 | | | 27 | | | 35 | | | 3 Pythium |
| | | | | | | | | | | 1 Fusarium |
| | | | | | | | | | | 1 Mucor |
| " | 0 | 8 | 10 | 43 | 70 | 59 | 43 | 78 | 65 | 2 Pythium |
| 7.Tillantin C | 4 | | | 39 | | | 43 | | | Pythium |
| " | 12 | 16 | 19 | 30 | 69 | 58 | 42 | 85 | 71 | None |
| 8.$CuCO_3$ (Corona) | 5 | | | 39 | | | 44 | | | 2 Pythium |
| | | | | | | | | | | 1 Phoma |
| | | | | | | | | | | 1 Fusarium |
| " | 14 | 19 | 16 | 48 | 87 | 72 | 62 | 106 | 88 | None |
| 9.$CuSO_4$+lime | 0 | | | 19 | | | 19 | | | None |
| " | 8 | 8 | 18 | 18 | 37 | 31 | 26 | 45 | 38 | None |
| 10.Formalin 1-240 | 6 | | | 19 | | | 25 | | | 1 Mucor |
| | | | | | | | | | | 1 Fusarium |
| " | 11 | 17 | 35 | 12 | 31 | 26 | 23 | 48 | 40 | 1 Pythium |
| 11.Tillantin B | 8 | | | 5 | | | 13 | | | 2 Pythium |
| " | 17 | 25 | 57 | 14 | 19 | 16 | 31 | 44 | 37 | 1 Pythium |

Table continued on next page.

Table III continued.

| Treatment | No. diseased seedlings. | | | Healthy seedlings at end of exp't. | | | Total no. seedlings emerging. | | | Organism |
|---|---|---|---|---|---|---|---|---|---|---|
| | Per row. | Total | % | Per row. | Total | % | Per row. | Total | % | |
| 12. Pasteurization 1. | 13 | | | 14 | | | 27 | | | 1 Pythium |
| " | 5 | 18 | 40 | 13 | 27 | 23 | 18 | 45 | 38 | None |
| 13. Pasteurization 2, | 7 | | | 8 | | | 15 | | | 1 Mucor. 1 Alternaria |
| " | 12 | 19 | 60 | 5 | 13 | 10 | 17 | 32 | 26 | None |
| 14. 93°C. | 7 | | | 11 | | | 18 | | | 1 Pythium |
| " | 15 | 22 | 50 | 11 | 22 | 19 | 26 | 44 | 37 | None |
| 15. 110°C. | 2 | | | 20 | | | 22 | | | None |
| " | 14 | 16 | 32 | 14 | 34 | 28 | 28 | 50 | 42 | 2 Pythium |
| 16. Large seed balls | 9 | | | 12 | | | 21 | | | None |
| " | 33 | 44 | 54 | 24 | 36 | 30 | 57 | 78 | 65 | 1 Mucor 2 Pythium |
| 17. Small seed balls | 3 | | | 3 | | | 6 | | | None |
| " | 6 | 9 | 60 | 3 | 6 | 5 | 9 | 15 | 13 | 1 Pythium 1 Mucor |
| 18. Hulled | None appeared above surface. | | | | | | | | | |
| " | " | " | " | " | " | " | | | | |
| 19. Check Av. 21 rows | 8 | | | 15 | | | 23 | | | 7 Pythium 5 Rhizoctonia 1 Phoma |
| " | 8 | 16 | 35 | 15 | 30 | 26 | 23 | 46 | 40 | |

Explanation of treatments in Table III.

1. Semesan was applied in dust form in excess.

2. Uspulun - an organic mercury compound furnished by Bayer Company, New York. One-fourth percent solution was applied for 1 hour.

3. $HgCl_2$ 1-1000 - applied for 1 hour.

4. DuPont #13 - mercury compound furnished by E. I. duPont de Nemours Co., Wilmington, Del. It is a dust applied in excess.

5. Pythal - as in Table I.

6. Chlorophol - as in Table I.

7. Tillantin C - a mercury compound furnished by H. A. Metz & Co., New York.

8. $CuCO_3$ (Corona) - as in Table I.

9. $CuSO_4$ + lime - as in Table I.

10. Formalin 1-240 - as in Table I.

11. Tillantin B - copper compound containing arsenic. Furnished by H. A. Metz & Co., New York.

12. Pasteurization 1 - Seed balls were placed in water at 60°C for 10 minutes.

13. Pasteurization 2 - Seed balls were heated as in #12 but on two successive days.

14. 93°C. The seed balls were placed in an oven at 93°C for 10 minutes.

15. 110°C. The seed balls were placed in an oven at 110°C. for 10 minutes.

16. Large seed balls - Same as #17 in Table I.

17. Small seed balls - Same as #18 in Table I.

18. Hulled - The seeds were hulled by pressing with a rotating motion between two blocks of wood.

19. Untreated American-grown seed.

## Discussion of Table III.

The average disease for the 21 untreated rows was 35 percent of those emerging having a stand of 26 percent of what could have been if all factors causing loss of seedlings had been removed. The total number appearing above the surface was 40 percent. All mercury compounds showed decrease in the amount of disease and an increase in stand as well as an increase in the number of seedlings that should appear.

Copper carbonate gave results superior to those from most of the mercury compounds used including $HgCl_2$ 1-1000 for one hour. Copper sulphate plus lime was not so good as the check. Tillantin B, a copper compound containing arsenic, appears to be of no value.

Formalin 1-240 for 1 hour gave about the same results as the average of the 21 untreated checks themselves.

Pasteurization at 60°C. for 10 minutes on one day or two successive days gave no indication of controlling seedling diseases. Although Phoma betae may be eliminated to a great extent the seedlings seem helpless against the soil organisms. Dry heat at 93°C. or 110°C. for 10 minutes were of no value as a means of preventing the disease.

The separation of the seed balls into lots of small ones and large ones seemed to be of no value, as in the previous test. An attempt was made to hull some seed from the ball. None of these seeds germinated or appeared above the surface. This is probably due to injury done to the seed in hulling.

In general, it can be said that every treatment showing a disease control better than the checks was either a mercury compound treatment or copper carbonate (Corona) treatment.

All diseased seedlings occurring on the last six days of this test were examined as given for Experiment #2. The duplicate rows were one half of the distance of the bed apart or the dittos represent one end of the bed. By this, it can be seen that the fungi causing the disease were well distributed throughout the soil. Especially was this true of Pythium.

Seven cultures of Rhizoctonia were found and five were on untreated rows. Three cultures of Phoma were found and one was from an untreated row. Mucors, Fusaria and Alternaria were looked upon as unavoidable saprophytes, however they may play a slight role in seedling diseases.

Experiment #4 - Sandy loam.

In order to repeat the same test and to see some of the effect of continuous cropping of beets the seedlings were removed and the soil well mixed. It was planted to sugar beets immediately as before.

Table IV shows results taken every afternoon over a period of 17 days after the seedlings began to appear.

Table IV.

| Treatment | No. diseased seedlings. | | | Healthy seedlings at end of exp't. | | | Total no. seedlings emerging. | | | Organism. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Per row. | Total | % | Per row. | Total | % | Per row. | Total | % | |
| 1. Semesan | 12 | | | 37 | | | 49 | | | 3 Pythium<br>4 Fusarium<br>3 No growth |
| " | 11 | 23 | 23 | 36 | 73 | 62 | 47 | 96 | 80 | 4 Phoma<br>4 Fusarium<br>1 Pythium<br>4 No growth |
| 2. Uspulun | 11 | | | 21 | | | 32 | | | 5 Pythium<br>1 Mucor<br>3 Fusarium<br>2 No growth |
| " | 7 | 18 | 25 | 32 | 53 | 45 | 39 | 71 | 60 | Rhizoctonia<br>2 Mucor<br>2 Bacteria<br>2 No growth |
| 3. $HgCl_2$ 1-1000 | 14 | | | 29 | | | 43 | | | 2 Pythium<br>4 Fusarium<br>3 Mucor<br>1 Penicillium<br>2 No growth |
| " | 11 | 25 | 30 | 26 | 55 | 57 | 37 | 80 | 67 | Phoma<br>3 Fusarium<br>3 Pythium<br>3 Mucor |
| 4. DuPont #13 | 13 | | | 35 | | | 48 | | | 8 Pythium<br>3 Mucor<br>1 Fusarium<br>1 No growth |
| " | 20 | 33 | 33 | 33 | 68 | 56 | 53 | 101 | 84 | 6 Pythium<br>1 Mucor<br>2 No growth |
| 5. Pythal | 3 | | | 33 | | | 36 | | | 2 Pythium<br>1 No growth |
| " | 5 | 8 | 14 | 16 | 49 | 40 | 21 | 57 | 48 | 1 Pythium<br>2 Fusarium<br>2 No growth. |
| 6. Chloropicrin | 2 | | | 33 | | | 35 | | | 1 Fusarium<br>1 Mucor |
| " | 6 | 8 | 9 | 44 | 77 | 65 | 50 | 85 | 71 | 3 Pythium<br>1 Rhizoctonia<br>1 Ascomycete<br>1 No growth |

Table continued on next page.

Table IV continued.

| Treatment | No. diseased seedlings. | | | Healthy seedlings at end of exp't. | | | Total no. seedlings emerging. | | | Organism. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Per row. | Total | % | Per row. | Total | % | Per row. | Total | % | |
| 7. Tillantin C | 13 | | | 7 | | | 20 | | | 6 Fusarium<br>2 Mucor<br>2 Pythium<br>2 No growth |
| " | 10 | 23 | 41 | 26 | 33 | 28 | 36 | 56 | 48 | 4 Fusarium<br>3 Mucor<br>2 Pythium |
| 8. $CuCO_3$ (Corona) | 9 | | | 29 | | | 38 | | | 6 Fusarium<br>3 Pythium |
| " | 13 | 22 | 32 | 18 | 47 | 40 | 31 | 69 | 56 | 3 Fusarium<br>3 Mucor<br>7 Pythium |
| 9. $CuSO_4$ + lime | 1 | | | 15 | | | 16 | | | 1 Pythium |
| " | 33 | 34 | 49 | 21 | 36 | 30 | 54 | 70 | 58 | 6 Pythium<br>6 Mucor<br>1 Phoma<br>4 Fusarium<br>11 Rhizoctonia |
| 10. Formalin 1-240 | 3 | | | 6 | | | 9 | | | 1 Pythium<br>1 Mucor<br>1 Fusarium |
| " | 1 | 4 | 44 | 1 | 7 | 6 | 2 | 11 | 10 | 1 No growth. |
| 11. Tillantin B | 12 | | | 10 | | | 22 | | | 4 Pythium<br>4 Mucor<br>2 Fusarium<br>2 No growth |
| " | 7 | 19 | 60 | 3 | 13 | 11 | 10 | 32 | 27 | 1 Pythium<br>1 Alternaria<br>1 Fusarium<br>2 No growth |
| 12. Pasteurization 1. | 5 | | | 0 | | | 5 | | | 1 Bacteria<br>1 Rhizoctonia<br>3 Fusarium |
| " | 7 | 12 | 92 | 1 | 1 | 1 | 8 | 13 | 11 | 2 Fusarium<br>3 Pythium<br>1 No growth |
| 13. Pasteurization 2. | 8 | | | 1 | | | 9 | | | 3 Pythium<br>3 Mucor<br>2 Fusarium |
| " | 4 | 12 | 86 | 1 | 2 | 2 | 5 | 14 | 12 | 3 Fusarium<br>1 Pythium |

Table continued on next page.

Table IV continued.

| Treatment | No. diseased seedlings. | | | Healthy seedlings at end of ext. | | | Total no. seedlings emerging. | | | Organism |
|---|---|---|---|---|---|---|---|---|---|---|
| | Per row. | Total | % | Per row. | Total | % | Per row. | Total | % | |
| 14.93°C. | 14 | | | 4 | | | 18 | | | 1 Phoma<br>4 Fusarium<br>3 Mucor<br>4 Pythium |
| " | 11 | 25 | 83 | 1 | 5 | 6 | 12 | 30 | 25 | 2 Pythium<br>4 Fusarium<br>1 Phoma<br>2 Mucor<br>1 No growth |
| 15.110°C. | 3 | | | 1 | | | 4 | | | 1 Alternaria<br>1 Pythium |
| " | 4 | 7 | 64 | 3 | 4 | 4 | 7 | 11 | 10 | 2 Pythium<br>1 Mucor |
| 16.Large seed balls | 10 | | | 12 | | | 22 | | | 4 Pythium<br>4 Fusarium<br>2 Mucor |
| " | 12 | 22 | 55 | 6 | 18 | 26 | 18 | 40 | 33 | 4 Fusarium<br>2 Pythium<br>1 Rhizoctonia<br>1 Mucor |
| 17.Small seed balls | 0 | | | 3 | | | 3 | | | |
| " | 1 | 1 | 17 | 2 | 5 | 6 | 3 | 8 | 5 | 1 Mucor. |
| 18.Hulled | None appeared above the surface of the soil. | | | | | | | | | |
| " | " | " | | " | " | | " | " | | |
| 19. Check (Av.21 rows) | 4.7 | | | 3.3 | | | 8 | | | 25 Pythium<br>8 Rhizoctonia |
| " | 4.7 | 9.4 | 60 | 3.3 | 6.6 | 5 | 8 | 16 | 15 | 1 Phoma<br>18 Mucor<br>18 Fusarium<br>2 Bacteria<br>5 No growth<br>7 Miscellaneous |

Explanation of treatments same as in Table III.

Discussion of Table IV.

Table IV is somewhat similar to Table II, although the bad effect of planting beets after beets is apparent by a general reduction in the number of seedlings appearing above the surface of the soil.

The 21 untreated rows showed 13 percent emerged (based upon the normal or ideal germination) and 60 percent of these became diseased, leaving a 5 percent stand of good seedlings. This shows a greater disease loss than shown in Table II, as the 21 untreated rows showed 40 percent emerged and 35 percent of these became diseased, leaving a 26 percent stand of good seedlings.

In comparing Table IV with Table II it can be seen that the same treatments have a similar rank in both when compared with the average of their checks.

The mercury compounds in general are best with copper carbonate (Corona), comparing well with $HgCl_2$ 1-1000 as in Table II, and superior to some mercury treatments. All other treatments gave no indications of control, as before.

A large number of Pythium cultures were found. In fact Pythium seemed to be as common on muck soil used in Table II. In few instances Phoma and Rhizoctonia were found. Rhizoctonia was more common on the untreated rows. Pythium was the most common of the three. A large number of cultures of Fusaria and Mucor were found. They were very difficult to eliminate. In fact some seedlings were treated with $HgCl_2$ 1-1000 so long they produced no growth.

Experiment #5 - Sand compared with soil.

The bed was divided into equal parts and the same soil

worked into one bed. Clean sand was put into the other. This should give a comparison of the effect of the seed-borne organisms and the soil organisms. The soil had shown heavy infection and Phoma betae had been found common on the seed balls. The seed and technique of planting were the same as before. Only the best of the treatments were used. Pasteurization at 60°C. for 10 minutes on two successive days was used as this treatment had been reported to give seed balls fairly free of Phoma betae. Table V represents a summary of records taken every afternoon over a period of 14 days after the seedlings began to appear.

Table V. On Soil.

| Treatment | No. diseased seedlings. | | | Healthy seedlings at end of ex't. | | | Total no. seedlings emerging. | | | Organism |
|---|---|---|---|---|---|---|---|---|---|---|
| | Per row. | Total | % | Per row. | Total | % | Per row. | Total | % | |
| Semesan | 12 | | | 38 | | | 50 | | | 5 Pythium<br>2 Fusarium<br>3 No growth. |
| " | 15 | 27 | 27 | 35 | 73 | 66 | 50 | 100 | 83 | 9 Pythium<br>4 No growth<br>2 Fusarium |
| DuPont #13 | 4 | | | 43 | | | 47 | | | 2 Pythium<br>2 Fusarium |
| " | 9 | 13 | 14 | 37 | 80 | 66 | 46 | 93 | 77 | 6 Pythium<br>3 Fusarium |
| Chlorophol | 7 | | | 33 | | | 40 | | | 2 Pythium<br>3 No growth<br>2 Bacteria |
| " | 4 | 11 | 12 | 45 | 78 | 65 | 49 | 89 | 74 | 2 Pythium<br>2 No growth |
| Uspulun | 12 | | | 32 | | | 44 | | | 8 Pythium<br>2 No growth |
| " | 17 | 29 | 36 | 21 | 53 | 44 | 38 | 82 | 68 | 5 No growth<br>2 Rhizoctonia<br>3 Fusarium<br>4 Pythium |
| $HgCl_2$ | 10 | | | 5 | | | 15 | | | 2 Fusarium<br>6 Pythium<br>2 No growth |
| " | 6 | 16 | 43 | 16 | 21 | 18 | 22 | 37 | 31 | 2 Fusarium<br>2 Pythium<br>1 No growth |
| $CuCO_3$ (Corona) | 4 | | | 15 | | | 19 | | | 1 Fusarium<br>2 Pythium<br>1 No growth |
| " | 13 | 17 | 32 | 21 | 36 | 30 | 34 | 53 | 44 | 11 Pythium |
| $CuSO_4$+lime | 6 | | | 12 | | | 18 | | | 5 Pythium<br>1 Fusarium |
| " | 10 | 16 | 40 | 12 | 24 | 20 | 22 | 40 | 34 | 1 Phoma<br>3 Pythium<br>1 Fusarium<br>2 No growth |
| Pasteurization #2. | 5 | | | 4 | | | 9 | | | 1 Phoma<br>4 Pythium |
| " | 5 | 10 | 46 | 8 | 12 | 10 | 13 | 22 | 18 | 2 Pythium<br>3 Fusarium |
| Check | 4.4 | | | 5 | | | 9.4 | | | 29 Pythium |
| " | 4.4 | 8.8 | 43 | 5 | 10 | 9 | 9.4 | 18.8 | 16 | 9 Fusarium |
| (Av. 11 rows | | | | | | | | | | 8 No growth<br>2 Bacteria |

All treatments are as in Table III.

Table VI. On Sand.

| Treatment | No. diseased seedlings. | | | Healthy seedlings at end of ext't. | | | Total no. seedlings emerged. | | | Organism |
|---|---|---|---|---|---|---|---|---|---|---|
| | Per row. | Total | % | Per row. | Total | % | Per row. | Total | % | |
| Semesan | 1 | | | 57 | | | 58 | | | 1 Phoma |
| " | 4 | 5 | 4 | 78 | 135 | 111 | 82 | 140 | 116 | 2 Phoma<br>2 No growth |
| DuPont #13 | 0 | | | 51 | | | 51 | | | |
| " | 3 | 3 | 3 | 44 | 95 | 78 | 47 | 98 | 81 | 2 Phoma |
| Chlorophol | 0 | | | 39 | | | 39 | | | |
| " | 1 | 1 | 1 | 42 | 81 | 67 | 43 | 82 | 68 | 1 Bacteria |
| Uspulun | 2 | | | 49 | | | 51 | | | 1 Phoma |
| " | 6 | 8 | 8 | 49 | 98 | 81 | 55 | 106 | 88 | 4 Phoma<br>2 No growth |
| $HgCl_2$ | 7 | | | 32 | | | 39 | | | 5 Phoma<br>1 No growth |
| " | 6 | 13 | 13 | 56 | 88 | 72 | 62 | 101 | 83 | 6 Phoma |
| $CuCO_3$ (Corona) | 6 | | | 37 | | | 43 | | | 3 Phoma<br>1 No growth |
| " | 8 | 14 | 15 | 39 | 76 | 64 | 47 | 90 | 75 | 6 Phoma<br>2 No growth |
| $CuSO_4$+ lime | 12 | | | 27 | | | 39 | | | 12 Phoma |
| " | 10 | 22 | 28 | 30 | 57 | 45 | 40 | 79 | 66 | 10 Phoma |
| Pasteurization #2 | 3 | | | 50 | | | 53 | | | 3 Phoma. |
| " | 1 | 4 | 4 | 54 | 104 | 86 | 55 | 108 | 90 | No growth<br>1 Phoma |
| Check (av.11 rows) | 11.5 | | | 22 | | | 33.5 | | | 106 Phoma<br>15 No growth |
| " | 11.5 | 23 | 23 | 22 | 44 | 34 | 33.5 | 67 | 56 | 4 Bacteria<br>2 Alternaria<br>3 Pythium |

All treatments as in Table III.

Discussion of Tables V and VI.

In the soil (Table V) which had its third crop of seedlings, the mercury compounds still showed considerable control. $CuCO_3$ again proved to be equal or superior to $HgCl_2$ 1-1000 for one hour. $CuSO_4$ + lime is not so good. The pasteurization treatment was about equal to the average of the eleven untreated rows.

When the data from the soil and sand (Table VI) are compared some very outstanding things are observed. First, the pasteurization which had proven to be of no value in the previous soil tests now ranked second. The qualities of Semesan are as outstanding in that this chemical applied in a dust form was equal to pasteurization as a means of sterilizing the seeds. One row of Semesan was exceptionally high in number of seedlings but with this reduced to that of the other rows Semesan would still be as good as pasteurization. Also $CuCO_3$ compares well with $HgCl_2$ as a means of freeing seed balls of Phoma betae.

The average of the eleven untreated rows gives some idea as to the real importance of Phoma betae. Thirty-three percent of the seedlings appearing above the surface of the sand became diseased, and with few exceptions Phoma was responsible for the disease. Three cultures of Pythium were found but they came from the buffer row nearest the row of bricks separating the sand and soil. Based upon the number that should have appeared if Phoma had been eliminated 44 percent were killed below the surface, leaving a final stand of 34 percent healthy seedlings. No examination was made for Phoma in the sand before planting but it was direct from a sand pit and

there is every reason to expect Phoma to be absent.

From this test as well as the previous experiments it is evident that the seed balls cannot be completely freed from Phoma betae by means of any of the large number of treatments tried. However, mercury compounds indicated a means of control. Copper carbonate was very promising in that it is a dust treatment as well as being a cheap chemical compound.

None of these treatments were a complete control for Phoma. With some treatments, such as that with Chlorophol, no Phoma appeared, but in view of the failure of the other mercury compounds to control this entirely, this treatment also would not be expected to give complete control.

Experiment #6.

To determine if there was an effect due to the physical nature of the soil entering into the results reported in Tables V and VI, the following experiment was performed.

Some of the soil and some similar sand were sterilized. New wooden greenhouse flats 3 inches deep and 16" x 20" were filled with this soil and sand, both sterilized and non-sterile. Three rows of 30 seed balls were planted in each. The middle row in each case was treated with Semesan. Twelve days after the seedlings began to appear the flats showed the following:

Table VII.

| | | Total stand. | Diseased. |
|---|---|---|---|
| Sterile sand | :Check | 25 | 4 |
| | :Semesan | 56 | 2 |
| | :Check | 28 | 2 |
| Sterile soil | :Check | 28 | 5 |
| | :Semesan | 58 | 2 |
| | :Check | 33 | 3 |
| Non-sterile sand | :Check | 27 | 3 |
| | :Semesan | 66 | 1 |
| | :Check | 40 | 2 |
| Non-sterile soil | :Check | 2 | 0 |
| | :Semesan | 16 | 1 |
| | :Check | 1 | 0 |

Discussion of Table VII.

This table shows that the physical nature of the soil had no influence in the previous results. The results in sand (sterile and non-sterile) and sterile soil were similar. This was the fourth crop of seedlings for the unsterilized soil and the checks were completely destroyed.

Inoculation Experiments.

Experiment #7.

To compare the pathogenicity of the three principal organisms causing seedling diseases the following experiment was performed.

Two strains of Phoma betae were used. One was isolated from a diseased seedling growing in sterile sand. The other was isolated from a sugar beet sent in from Colorado. The Rhizoctonia was from a diseased seedling and also a strain from

potato was used. The Pythium debaryanum was isolated from a diseased seedling from the soil in greenhouse bed.

About three weeks before planting the beets these organisms were started on 300 gr. of sterile cornmeal. The sand was sterilized as well as the greenhouse flats. The cornmeal with a good growth of the fungus was thoroughly mixed with the seed. The seeds were planted immediately in three rows across the flat containing 50 seed balls. The middle row was treated with Semesan dust in excess. The results were as follows:

Table VIII.

| | | No. seedlings. | | |
|---|---|---|---|---|
| | | No. emerged | No. diseased. | Organisms. |
| Phoma from sugar beet seedling. | Check | 1 | 1 | Phoma |
| | Semesan | 1 | 1 | Phoma |
| | Check | 0 | 0 | |
| Phoma from Colorado. | Check | 0 | 0 | |
| | Semesan | 7 | 7 | 6 Phoma<br>1 Mucor |
| | Check | 2 | 2 | 1 Phoma |
| Pythium debaryanum, from seedling. | Check | 0 | 0 | |
| | Semesan | 0 | 0 | |
| | Check | 0 | 0 | |
| Rhizoctonia from seedling. | Check | 16 | 2 | 2 Rhizoctonia |
| | Semesan | 52 | 15 | 13 Rhizoctonia<br>1 No growth<br>1 Alternaria |
| | Check | 39 | 9 | 9 Rhizoctonia |
| Rhizoctonia from potato. | Check | 25 | 7 | 4 Rhizoctonia<br>2 Mucor |
| | Semesan | 39 | 11 | 5 Rhizoctonia<br>2 Mucor |
| | Check | 34 | 12 | 4 Rhizoctonia<br>2 Mucor |
| Mixture of Phoma, Pythium and Rhizoctonia, from seedlings. | Check | 9 | 5 | 5 Rhizoctonia<br>1 Pythium |
| | Semesan | 26 | 20 | 2 Phoma<br>2 Pythium<br>12 Rhizoctonia |
| | Check | 11 | 8 | 1 Phoma<br>6 Rhizoctonia |
| Sterile cornmeal. | Check | 30 | 6 | 4 Mucor<br>1 Alternaria |
| | Semesan | 34 | 3 | 1 Bacteria<br>1 Mucor |
| | Check | 26 | 10 | 2 Phoma<br>5 Mucor<br>1 Bacteria |

Table VIII continued.

| | | No. seedlings. | | |
|---|---|---|---|---|
| | | No. emerged | No. diseased. | Organisms. |
| Sterile sand only. | Check | 40 | 5 | 1 Phoma<br>3 Bacteria<br>1 Alternaria |
| | Semesan | 44 | 0 | |
| | Check | 40 | 1 | 1 Mucor. |

Discussion of Table VIII.

Pythium was the most effective parasite, as not a single seedling appeared above the surface of the sand. However, on digging into the sand, seed balls could be found with the young seedling attached which was killed before it reached the surface. In inoculation of this kind Semesan was not able to ward off the organism as previous soil tests had indicated.

Phoma betae was almost as effective as Pythium. However, a few seedlings came above the surface in each culture but beets were soon diseased.

Rhizoctonia was quite different from the other two. A very good growth of the organism was obtained before the seedlings began to appear. In fact, the seedlings came through the surface colored brown with the fungus. The first twelve days indicated that Rhizoctonia, at least in these strains, was not a very important organism. Twenty-four days after the seedlings began to appear the flats were destroyed. Special attention was given the Rhizoctonia

inoculated flats and each seedling examined. It was found that almost every seedling from the check rows in both flats had a decayed root tip. The Semesan rows were some better. The strain from potato seemed to be as effective, if not more so, than the one from the beet seedlings. The root tip was more or less decayed and the plant had from 3 to 8 small rootlets just above this decayed region that seemed to be replacing the original tip. The hypocotyl was sound above the surface, however the leaves had a light green color. Very few showed signs of wilting. No doubt in many cases the seedling would have won and produced a beet if given a chance. It seems that the sprangled or forked beets so common in some fields can be explained as a result of a combat between the seedling and Rhizoctonia during its early stages of growth, rather than high water table or impervious subsoil as often suggested.

The mixture was made by adding some sand inoculated with Phoma betae (seedling), Rhizoctonia (seedling) and Pythium debaryanum (seedling) to a flat and mixing. The inoculum was not added in nearly as great quantities as in the other flats. Only a few cultures of Phoma or Pythium were reisolated from this flat. Rhizoctonia was the most common of the three, by far. This may seem strange at first since Pythium and Phoma were so effective when alone. It can, no doubt, be explained by saying that the seedlings attacked by Phoma and Pythium were killed before they reached the surface as in the flats with Pythium or Phoma alone. This will also explain why Phoma

was so seldom found on seeds from soil when it was known to be common on the seed balls.

One flat with cornmeal alone was used to see the effect of introducing the meal on which the organisms grew. The total number of seedlings were reduced but this is probably due to the cornmeal acting as a medium for organisms from the seed balls.

The sterile sand alone was much like the previous test on sand. Phoma was isolated from a diseased seedling.

## Summary.

The sugar beet industry is an important phase of Michigan agriculture.

Sugar beets are planted on sandy loam soil as well as on muck. The seed balls are planted heavily in drills but even this method of seeding fails to produce a stand.

The common cause of failure to get a stand is fungous attack which gives rise to the so-called "seedling diseases".

Previous workers have shown that Phoma betae, Pythium debaryanum, Aphanomyces laevis, Rhizoctonia spp. and Rheosporangium aphanidermatum are the principal organisms causing seedling diseases of sugar beets in Europe and America.

Phoma betae has been found to be universally present on sugar beet seed balls.

There are at least three distinct signs of seedling diseases.

Phoma betae was found common on sugar beet balls from isolated breeding plots in the vicinity of Lansing, Michigan.

Test for seed treatments could not successfully be made between absorbent paper or sand in moist chambers. Tall battery jars containing sterile quartz were very good for testing small lots of seed balls.

Experiments on muck soil in greenhouse indicated that seedling diseases could be reduced by means of mercury and copper compounds applied to the seed balls.

Pythium debaryanum was found to be the most common organism associated with diseased seedlings from muck soil.

On sandy loam soil the results were similar to those on muck soil, as far as the disease was concerned.

Pasteurization at 60°C. for 10 minutes on two successive days proved to be a very effective treatment when the soil organisms were absent, but of no value in infested soil.

Test in sand showed that 33 percent of all seedlings may be killed by Phoma betae after they appear above the surface, and that 64 percent stand of healthy seedlings is obtained in comparison with what should be expected for an ideal germination.

No complete control was found. However, copper carbonate and mercury compounds gave control.

The physical nature of the soil did not influence the percent of diseased seedlings.

Inoculation experiments showed that Phoma betae and Pythium debaryanum were very strong and rapidly-working parasites. Rhizoctonia is almost as effective in producing seedling diseases of sugar beets but slower in its action.

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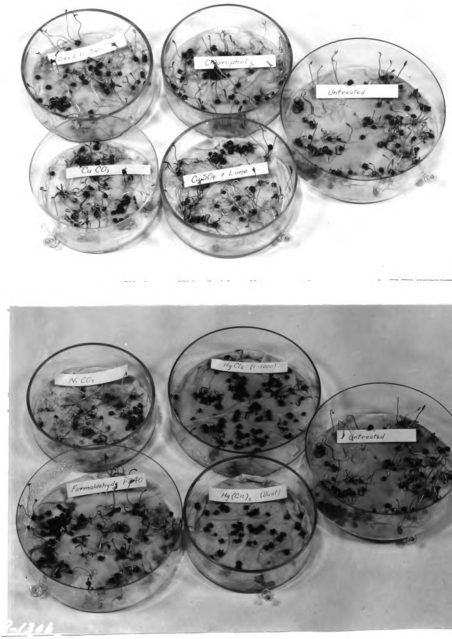


Plate I. Seed treated and planted between absorbent paper. Showing effect of certain chemicals on the roots. (Preliminary experiment.)


Plate II. Showing part of the bed of seedlings. (Table I.)


Plate III. Comparing copper carbonate (Corona) and check row. (Table I.)


Plate IV. Showing part of the bed of seedlings. (Table II.)


Plate V. Showing part of bed of seedlings. (Table III.)


Plate VI. Showing part of bed of seedlings. (Table III.)


Plate VII. Showing portion of bed of seedlings. (Table IV.)


Plate VIII. Showing a part of bed of seedlings.
(Table V.)

Plate IX. Showing part of bed of seedlings. (Table VI.)

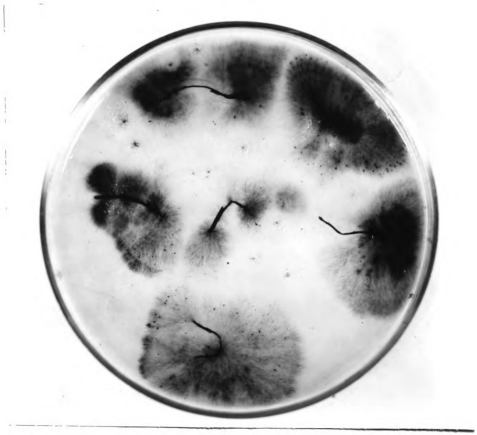

Plate X. These seedlings were taken from bed.(Table VI.)
Note each seedling shows Phoma betae.


Plate XI. Inoculated flats. (Table VIII).

Flat #1 = Check.
Flat #2 = Rhizoctonia from seedling.
Flat #3 = Pythium from seedling.
Flat #4 = Phoma from seedling.


Plate XII. Sterile sand flat. (Table VIII.)

Plate XIII. Rhizoctonia inoculated flat. (Table VIII.)

Plate XIV. Typical Rhizoctonia infected seedlings from flat shown in Plate XIII. Note the enlarged roots above the decayed region.