POTATO SPRAYING EXPERIMENTS IN 1903.

F. C. STEWART, H. J. EUSTACE AND F. A. SIRRINE.
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* Connected with Fertilizer Control.
† Absent on leave.
‡ In Second Judicial Department.
BULLETIN No. 241.

POTATO SPRAYING EXPERIMENTS IN 1903.

F. C. STEWART, H. J. EUSTACE AND F. A. SIRRINE.

SUMMARY.

This bulletin gives the results of the second year's work on the ten-year potato spraying experiments begun in 1902; also, an account of six business experiments conducted by farmers.

The results of the ten-year experiments for 1903 are as follows:--

At Geneva, the rows sprayed three times yielded at the rate of 262 bushels per acre; those sprayed five times, 292, and those not sprayed, 174. Thus, three sprayings increased the yield 88 bushels per acre and five sprayings, 118 bushels. The increase in yield on the sprayed rows was due, almost wholly, to the better protection against late blight.

On Long Island the rows sprayed three times yielded at the rate of 246½ bushels per acre; those sprayed five times, 263 and those not sprayed, 207. The increased yield due to three sprayings was 39½ bushels per acre, while that due to five sprayings amounted to 56 bushels per acre. The increase in yield was due, chiefly, to better protection against late blight and flea-beetles.

The farmers' business experiments were designed to determine the actual profit in spraying potatoes under ordinary farm conditions. The increase in yield was determined and an account kept of all expense. Late blight being destructive, the spraying proved highly profitable. On the total area of 61½ acres sprayed in
the six experiments in different parts of the State there
was a total increase in yield of 3746 bushels, or an
average of 61.24+ bushels per acre. At 50 cents per
bushel the increase was worth $1873. Subtracting
from this amount the total expense of the spraying,
$296.49, there is a remainder of $1576.51 which is the
total net profit. This is at the rate of $25.77+ per
acre.

It is estimated that the loss from potato blight in
New York in 1903 was fifty bushels per acre on the
average. Since the area devoted to potatoes in the
State is about 396000 acres and the average price of
potatoes in the fall of 1903 was fifty cents per bushel,
the total loss sustained by New York farmers in a sin-
gle season was nearly $10,000,000. A large part of
this loss might have been prevented by spraying.
INTRODUCTION.

During the past season the Station has continued the ten-year potato-spraying experiments begun in 1902. These experiments are designed to determine how much the yield of potatoes can be increased, on the average, by spraying with bordeaux mixture. The plan is to continue the experiments during ten consecutive seasons and take the average increase in yield as the index of the value of spraying potatoes in New York State. The experiments are to be conducted in two localities; namely, at Geneva and at Riverhead. Two methods of spraying are to be compared as to their efficiency: Some rows are sprayed every two weeks regularly while others are sprayed only three times during the season. At each place the area of the experiment field is to be three-tenths of an acre each season. The rows sprayed every two weeks alternate with those sprayed only three times and with others not sprayed at all. For further details see Bulletin 221.

In addition to the above experiments the Station has, during the season of 1903, coöperated with five farmers in making experiments designed to determine the net profit in spraying potatoes in different ways under ordinary farm conditions.

1 A full account of the experiments and the results obtained in 1902 are given in Bulletin 221 of this Station.
SUMMARY OF RESULTS OBTAINED IN TEN YEAR EXPERIMENTS IN 1902.

Table I.—Yield by Series at Geneva in 1902.

<table>
<thead>
<tr>
<th>Series</th>
<th>Rows</th>
<th>Dates of spraying</th>
<th>Yield per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>2, 5, 8 and 14.</td>
<td>June 25, July 10, 23, 30, Aug. 12, 26 and Sept. 10.</td>
<td>lbs. 41</td>
</tr>
<tr>
<td>III</td>
<td>3, 6, 9 and 15.</td>
<td>Not sprayed.</td>
<td>342 36</td>
</tr>
</tbody>
</table>

Gain due to spraying three times 98\(1/3\) bushels per acre.
Gain due to spraying seven times 123\(3/4\) bushels per acre.

Table II.—Yield by Series at Riverhead in 1902.

<table>
<thead>
<tr>
<th>Series</th>
<th>Rows</th>
<th>Dates of spraying</th>
<th>Yield per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>2, 5, 8 and 11.</td>
<td>May 26, June 20 and July 22.</td>
<td>Bu. 295</td>
</tr>
<tr>
<td>II</td>
<td>1, 4, 7 and 10.</td>
<td>May 26, June 3, 20, 30, July 11, 23 and Aug. 5.</td>
<td>lbs. 20</td>
</tr>
<tr>
<td>III</td>
<td>3, 6, 9 and 12.</td>
<td>Not sprayed.</td>
<td>312 35</td>
</tr>
</tbody>
</table>

Gain due to spraying three times 27\(3/4\) bushels per acre.
Gain due to spraying seven times 45 bushels per acre.

DETAILS OF TEN-YEAR EXPERIMENTS IN 1903.

FITTING, PLANTING, CULTIVATION, ETC.

At Geneva.—The land used was a thinly seeded clover sod. It was plowed May 21, 1903. Owing to severe drought the growth of clover was light; and the soil, being a heavy clay loam, turned up in large, dry, hard lumps which were difficult to pulverize. On May 25 it was fitted by going over it four times with a spring tooth harrow and clod crushe. Even after this treatment the soil was lumpy and poorly fitted.
The rows were marked out three feet apart and the furrows opened with a plow. Fertilizer, at the rate of 1000 pounds per acre was scattered in the furrows. Planting was done May 25 and 26, care being taken to place the seed pieces exactly 15 inches apart in the row. They were covered four inches deep by means of hoes.

The seed was of the variety Rural New Yorker No. 2 and had been selected from the sprayed rows in the experiment of 1902. A few days before planting time the seed tubers were given the formalin treatment for scab and then cut into pieces of the size of a hen's egg without regard to the number of eyes except that each piece bore at least one eye.

During the season the plants were hoed once and cultivated three times. After the last cultivation they were hilled, moderately, with a shovel plow.

The soil was a heavy clay loam with some gravel in it. The field sloped rapidly toward the north giving good surface drainage.

At Riverhead.—The previous crop was cauliflower over the north half of the field and an asparagus seed-bed over the south half. The land was plowed 6 to 8 inches deep April 28 and harrowed twice. After treatment with formalin for scab, planting was done by hand on April 29 with pieces of hen's egg size, placed 15 inches apart in the row and the rows 3 feet apart. The seed used was of the variety Carman No. 1 taken from the sprayed rows in the experiment of 1902.

The trenches for planting were opened with a double moldboard plow. Home-mixed fertilizer having the formula 4-12-4 and costing $26 per ton was sown in these trenches by hand at the rate of 1000 pounds per acre. Before planting, the fertilizer was mixed with the soil by running through the trenches a broad shovel attached to a one-horse cultivator. The seed pieces were covered to a depth of 3 to 5 inches by means of the same one-horse cultivator with side hoes attached. Afterward the rows were levelled off by harrowing.

* South Carolina rock 555 lbs. and ground blood (10 per ct.) 445 lbs.
3 Tubers soaked two hours in a solution containing one pint of formalin in 30 gallons of water.
Further cultivation consisted of two harrowings (one three days before, and the other five days after, the plants came up), one cross working with a Hallock weeder, one hand hoeing to remove volunteer asparagus, and four cultivations (one deep, three shallow) with a horse cultivator. The plants were not hilled. The soil was of practically the same character as that used in 1902, namely, a well-drained sandy loam containing some gravel.

**PREPARATION AND APPLICATION OF THE BORDEAUX MIXTURE.**

Both at Geneva and at Riverhead the bordeaux mixture used was of the 1-to-8 formula the same as in 1902. At Geneva it was applied with a knapsack sprayer and very thoroughly. Again it was found almost impossible to spray the rows of Series I and II without getting some of the mixture on the unsprayed rows of Series III.

At Riverhead, the rows in Series I (to be sprayed three times) were sprayed with a horse machine carrying five Vermorel nozzles per row and applying the bordeaux at the rate of 100 gallons per acre. The rows in Series II (to be sprayed every two weeks) were given three sprayings with the same machine and on the same dates as for Series I. The additional two sprayings given Series II were made with a knapsack sprayer.

**DATES OF SPRAYING.**

*At Geneva: Series I.*—This series, consisting of rows 1, 4, 7, 10 and 13, was sprayed three times with bordeaux mixture—July 14, 28 and August 26. The first spraying, July 14, was necessitated by the appearance of "bugs" in injurious numbers. At this time the plants were about a foot high. To poison the "bugs" white arsenic was used with the bordeaux in the proportion of one quart of the stock solution to 50 gallons of bor-

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4 Formula for stock solution of white arsenic:
- 2 lbs. white arsenic.
- 8 lbs. salsoda (washing soda).
- 2 gallons water.

Boil until dissolved. As a poison, one pound of white arsenic is equal to two pounds of paris green.
deaux. Three days later there were to be seen only a few "bugs" and no evidence that the arsenic had injured the foliage.

On July 28 a second brood of "bugs" appeared and it was deemed advisable to poison them. Moreover, the weather was favorable to late blight. Accordingly, a second spraying of the rows in this series was made July 28 with bordeaux and white arsenic mixed in the same proportions as in the previous spraying. Again the "bugs" were killed without any injury to the foliage and there was no further trouble with them during the season.

The third and last spraying on this series was made August 26 with bordeaux alone. Since there were no "bugs" it was unnecessary to use poison. It appears that this was a time when the rows in this series were much in need of spraying for protection against late blight. They had not been sprayed for four weeks and no bordeaux was to be seen upon them. During the previous three or four days the weather had been wet and "muggy." In some fields northwest of Geneva there was already considerable blight. It was also abundant in a patch of early potatoes a few rods from the experiment and there were even traces of the disease all along the unsprayed rows in the experiment field. Undoubtedly, it was this third spraying which gave Series I its protection against late blight. Probably the results would have been better if it had been made two or three days earlier.

**Series II.**—This series consisted of rows 2, 5, 8, 11 and 14. The plants were sprayed five times—July 7, 21, August 7, 21 and September 3. At the time of the first spraying the plants were six to eight inches high. On this series it was necessary to use poison but once, namely, in the second spraying, July 21. The early spraying of July 7 seems to have discouraged the "bugs" so that as late as July 21 there were but few of them on this series, although they were abundant on the other two unsprayed series a week earlier. Two days after spraying with bordeaux and white arsenic there were no live "bugs" and no injury to the foliage.

5 White arsenic, one quart stock solution to 50 gallons of bordeaux.
Up to the time of the fourth spraying, August 21, no trace of late blight had been found anywhere in the experiment field, but it made its appearance three days later. The fifth spraying, September 3, was made while the blight epidemic was at its height. According to our plan for spraying this series regularly every two weeks a sixth spraying should have been made September 17, but the plants were so much blighted that it was thought it would not pay to spray them again.

**Series III.**—Series III consisted of rows 3, 6, 9, 12 and 15. They were not sprayed at all with bordeaux but were treated twice (July 14 and 28) with white arsenic in lime water to kill the "bugs." The white arsenic was used at the same rate as on Series I and II; that is, one quart of stock solution to 50 gallons of lime water.

Three days after the first treatment nearly all of the plants showed slight injury. It appears that too little lime was used with the arsenic. The quantity was not measured, but guessed at, and was thought to be ample. In the second treatment care was taken to use an abundance of lime and no injury resulted. In both treatments the "bugs" were practically all killed.

**At Riverhead: Series I.**—This series consisted of four rows—Nos. 1, 4, 7 and 10, which were sprayed with bordeaux mixture three times; namely, on June 5, July 22 and August 7. Poison (white arsenic) was used in all three sprayings at the rate of one pint of the stock solution to 50 gallons of bordeaux.

**Series II.**—This series consisted of four rows—Nos. 2, 5, 8 and 11. They were sprayed with bordeaux mixture five times; namely, on June 5, 24, July 7, 22 and August 7. As on Series I, poison was used with every application. Perhaps it was unnecessary to use poison so frequently, but as there were always a few flea-beetles and a few "bugs" and the poison cost so little it was the best.

**Series III.**—Series III, also, consisted of four rows,—Nos. 3,
6, 9 and 12. The rows of this series were not sprayed at all with bordeaux, but when the "bugs" appeared in destructive numbers (July 7) they were promptly treated with white arsenic, one pint of the stock solution in 50 gallons of lime water. This one treatment freed the plants from "bugs" and there was no further trouble with them.

THE RESULTS OF THE TEN-YEAR EXPERIMENTS.
AS INDICATED BY THE CONDITION OF THE FOLIAGE.

At Geneva.—Potato bugs did no appreciable damage to any of the plats. Twice they appeared in considerable numbers, but were promptly killed before they did any damage. Although poison was used with the bordeaux but once on the rows in Series II, "bugs" were less numerous on this series than on Series I where it was necessary to use the poison twice. On July 14 young "bugs" were so numerous on Series I and III, that it was absolutely necessary to poison them to prevent serious injury to the plants. At the same time there were but a few on Series II and even a week later there were so few that it was a question whether it was worth while to poison them.

The explanation of this seems to be the fact that Series II was sprayed with bordeaux a week earlier than Series I and some of the young "bugs," which were hatching about that time, were killed by feeding on the heavily-sprayed foliage. It is unlikely that they migrated to the unsprayed plants because they were too young to migrate. Similar observations were made in 1902 but interpreted differently. (See Bul. 221, p. 245.) Whatever the true explanation of it may be the fact is established that plants thoroughly sprayed with bordeaux mixture are much freer from "bugs" than are unsprayed plants.

About July 10 flea-beetles were quite numerous for a few days and again about September 1 they were considerably in evidence, but at no time did they materially injure the plants. However, their work was more noticeable on the unsprayed than on the sprayed plants.

There was no injury whatever from early blight, Alternaria solani and certainly none from drought. Nevertheless, some of
the plants on all the rows were slightly affected with a browning of the leaf margins the cause of which we were unable to determine. This was first observed July 11 before the plants were a foot high and continued to be noticeable throughout the season. The leaves were slightly curled and the margins brown. The worst-affected plants died prematurely. The damage done was not great anywhere and was least on the rows sprayed every two weeks. It could not have been due to arsenic injury because it appeared before any arsenic had been used. There was, however, slight arsenic injury on the rows in Series III resulting from the first application of arsenic in lime water July 14. (See page 258).

Although carefully watched for, no trace of late blight, Phytophthora infestans, was found in the experiment field until August 24. Up to this time the sprayed rows were no better than the unsprayed except that they showed somewhat less injury from the unknown tipburn. The plants were looking well. In places they met between the rows but the ground was not entirely covered by them. Immediately after its first appearance the blight spread rapidly. It soon became evident that the north (lower) end of the field would suffer most. Not only was the soil here wetter and the air circulation poorer but there was also a small patch of blight-infested early potatoes not more than twenty feet distant.

At the north end, the unsprayed rows had lost a large part of their foliage by September 1, and what remained was badly spotted. There were also a good many points of infection on the rows sprayed three times (Series II) but the rows sprayed every two weeks (Series I) were almost perfect in foliage. At the south end of the field there was little if any contrast in appearance between the sprayed and unsprayed rows, although the latter were slightly affected.

On September 3 the unsprayed rows, at the north end, were pronounced dead.

On September 7, at the north end, the 3-sprayed rows were sufficiently attacked to affect their growth slightly and by September 14 they were dead. The rows sprayed every two weeks lived until September 21. Thus it appears that, at the north
end of the field, three sprayings prolonged the life of the plants 11 days while 5 sprayings prolonged it 18 days.

At the south end of the field the 3-sprayed rows outlived the unsprayed by fully three weeks and were finally pronounced dead on October 3; while the rows sprayed every two weeks lingered along until October 7.

At Riverhead.—In the experiment at Riverhead no damage was done by "bugs." They appeared in considerable numbers about July 7 but were promptly poisoned. Flea beetles were plentiful about June 5 and again about August 14. On the latter date they suddenly appeared in swarms. It seems probable that they migrated to the experiment field from neighboring fields which were killed by blight about that time. The unsprayed rows were already nearly dead from blight and the flea-beetles soon finished the sprayed rows which, at that time, still had about two thirds of their foliage.

Early blight caused slight damage to the unsprayed plants, but the chief enemy was late blight, Phytophthora infestans, which made its first appearance in the experiment field on July 25. In some neighboring fields it had been present since July 15. During the second week in August there was a general epidemic of blight. In the experiment field the unsprayed rows suffered much more than the sprayed although the latter became considerably affected by August 15. The contrast in appearance between the sprayed and unsprayed rows was at no time as great as in 1902 although the increase in yield due to spraying was somewhat greater in 1903 than in 1902.

The unsprayed rows died about August 16 while the sprayed rows continued green several days longer, those of Series II, holding out until September 1.

AS SHOWN BY THE YIELD.

At Geneva.—The potatoes were dug by hand October 22 and 23. As in 1902, the product of each row was sorted into two grades, marketable and culls, and the weight of each grade taken. All tubers larger than a hen's egg were graded as marketable. The sorting was all done by the writers and as uniformly as possible.
TABLE III.—YIELDS IN THE EXPERIMENT AT GENEVA.

<table>
<thead>
<tr>
<th>Section</th>
<th>Row</th>
<th>Treatment</th>
<th>Yield per row</th>
<th>Yield per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Marketable</td>
<td>Culls</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lbs.</td>
<td>Lbs.</td>
</tr>
<tr>
<td>A</td>
<td>1</td>
<td>Sprayed 3 times</td>
<td>309</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Sprayed 5 times</td>
<td>334</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Unsprayed</td>
<td>191</td>
<td>23</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>Sprayed 3 times</td>
<td>290</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Sprayed 5 times</td>
<td>343</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Unsprayed</td>
<td>210</td>
<td>22</td>
</tr>
<tr>
<td>C</td>
<td>7</td>
<td>Sprayed 3 times</td>
<td>330</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Sprayed 5 times</td>
<td>346</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Unsprayed</td>
<td>205</td>
<td>22</td>
</tr>
<tr>
<td>D</td>
<td>10</td>
<td>Sprayed 3 times</td>
<td>314</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Sprayed 5 times</td>
<td>360</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Unsprayed</td>
<td>212</td>
<td>24</td>
</tr>
<tr>
<td>E</td>
<td>13</td>
<td>Sprayed 3 times</td>
<td>329</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Sprayed 5 times</td>
<td>370</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Unsprayed</td>
<td>228</td>
<td>22</td>
</tr>
</tbody>
</table>

Comments on the table.—A study of the above table reveals the following: (1) In each of the five sections the five-sprayed row yielded more than the three-sprayed row, the difference varying from 13 to 44 bushels per acre.

(2) In each section the sprayed rows yielded more than the unsprayed row, the difference between the five-sprayed row and the adjacent unsprayed row varying from 110 to 124 bushels per acre.

(3) In different sections the yield of rows treated in the same way varied considerably. The yield of the unsprayed rows varied from 159 to 190 bushels per acre; on the three-sprayed rows it varied from 241 to 275 bushels per acre; and on the five-sprayed rows, from 278 to 308 bushels. This variation is partly due to the fact that blight was more severe on the west side of the field than on the east, and partly to slight variations in soil in different parts of the field. It is impossible to avoid such variations entirely, but by alternating the sprayed with the unsprayed rows as in this experiment they have little influence on the results. The difference between the average of the
five unsprayed rows and the average yield of the five rows sprayed five times may be safely taken as the result of the spraying.

_Yield by series._—The five rows sprayed three times constitute Series I and the average yield of these five rows make the yield of Series I. The yields given for Series II and III have been computed in the same manner. The yield by series is shown in the following table:—

<table>
<thead>
<tr>
<th>Series</th>
<th>Rows</th>
<th>Dates of spraying</th>
<th>Yield per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1, 4, 7, 10 and 13</td>
<td>June 5, July 22 and Aug. 7.</td>
<td>Bu. 262</td>
</tr>
<tr>
<td>II</td>
<td>2, 5, 8, 11 and 14</td>
<td>June 5, 24, July 7, 22, and Aug. 7.</td>
<td>—</td>
</tr>
<tr>
<td>III</td>
<td>3, 6, 9, 12 and 15</td>
<td>Not sprayed.</td>
<td>292 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>174 20</td>
</tr>
</tbody>
</table>

*Increase in yield due to spraying three times, 88 bushels per acre.*
*Increase in yield due to spraying five times, 118 bushels per acre.*

The difference in the appearance of the foliage on Series I and II, although somewhat greater than in 1902, was, nevertheless, quite small and seemed insufficient for a difference in yield of 30 bushels per acre.

The impossibility of correctly estimating differences in yield by the eye is shown even more strikingly in Plate III, which is from a photograph of Rows 11, 12 and 13 as the tubers lay on the ground after digging. The average observer would say that the yield on the row sprayed every two weeks was certainly somewhat greater than that on the unsprayed row, and that, probably, the row sprayed three times would outyield the unsprayed row by a few bushels per acre; but only one having much experience in making such estimates would expect to find the differences anything like as great as they really were. As a matter of fact the row sprayed every two weeks outyielded the unsprayed row by 123 bushels per acre; and the row sprayed three times outyielded it by 97 bushels per acre. (See table on page 262.) The explanation of the matter is this:—On the
unsprayed row there were nearly as many tubers as on the sprayed rows, but each tuber was a little smaller. The eye notes the number of tubers rather than their size. The only fair way to determine the increase in yield in spraying experiments is to weigh or measure the tubers.

Loss from rot.—In spite of the severe attack of late blight (Phytophthora) on the unsprayed rows there was only a small amount of rot among the tubers. There seems to have been less rot than in 1902 when it was estimated to be 7.6 per ct.\(^8\) The increased yield on the sprayed rows was due chiefly to the prolongation of the life of the plants and to only a small extent to the prevention of rot.

At Riverhead.—The potatoes were dug on September 8 and sorted into two grades, marketable tubers and culls, in the same manner as at Geneva.

<table>
<thead>
<tr>
<th>Section</th>
<th>Row</th>
<th>Treatment</th>
<th>Yield per row</th>
<th>Yield per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Marketable</td>
<td>Culls</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lbs. oz.</td>
<td>Lbs. oz.</td>
</tr>
<tr>
<td>A</td>
<td>1</td>
<td>Sprayed 3 times</td>
<td>345</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Sprayed 5 times</td>
<td>360</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Unsprayed</td>
<td>300</td>
<td>70</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>Sprayed 3 times</td>
<td>341</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Sprayed 5 times</td>
<td>394</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Unsprayed</td>
<td>289</td>
<td>70</td>
</tr>
<tr>
<td>C</td>
<td>7</td>
<td>Sprayed 3 times</td>
<td>396</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Sprayed 5 times</td>
<td>388</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Unsprayed</td>
<td>296</td>
<td>65</td>
</tr>
<tr>
<td>D</td>
<td>10</td>
<td>Sprayed 3 times</td>
<td>397</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Sprayed 5 times</td>
<td>437</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Unsprayed</td>
<td>356</td>
<td>47</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Marketable</th>
<th>Culls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lbs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bu.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lbs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bu.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lbs.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments on the table.—Again, as in 1902, the difference in yield between the sprayed and unsprayed rows was much smaller at Riverhead than at Geneva. There was a severe attack of late blight (Phytophthora) which was only partially prevented by the

\(^8\)See Bulletin 221 of this Station, p. 251.
PLATE II.—ROWS 11, 12 AND 13 IN EXPERIMENT AT GENEVA.
(Photographed Sept. 16.)
PLATE III.—Rows 11, 12 and 13 in Experiment at Geneva.

Per acre—300 lbs.

177 lbs.

174 lbs.

(See page 202.)
Plate IV.—Total Yield in Experiment at Geneva.
spraying, even on the rows sprayed every two weeks. Toward the close of the growing period the plants were attacked by hordes of hungry flea-beetles coming from the neighboring blighted fields. Since the unsprayed rows were already dead the sprayed rows, alone, suffered from this attack and the death of the plants was undoubtedly hastened. Had it not been for flea-beetles the difference in yield between the sprayed and unsprayed rows would probably have been considerably greater.

In all four sections each of the sprayed rows yielded more than the unsprayed row, and, with one exception, Section C, the row sprayed five times outyielded the row sprayed three times. It is not known how it came about that Row 7 (sprayed three times) yielded six bushels per acre of marketable tubers more than Row 8 (sprayed five times).

Yield by series.—The yield by series is shown in the following table:

<table>
<thead>
<tr>
<th>Series</th>
<th>Rows</th>
<th>Dates of spraying</th>
<th>Yield per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1, 4, 7 and 10</td>
<td>June 5, July 22 and Aug. 7.</td>
<td>246, 45</td>
</tr>
<tr>
<td>II</td>
<td>2, 5, 8 and 11</td>
<td>June 5, 24, July 7, 22 and Aug. 7.</td>
<td>263, 10</td>
</tr>
<tr>
<td>III</td>
<td>3, 6, 9 and 12</td>
<td>Not sprayed.</td>
<td>207, 10</td>
</tr>
</tbody>
</table>

Increase in yield due to spraying three times, 39½ bushels per acre. Increase in yield due to spraying five times, 56 bushels per acre.

Loss from rot.—Among the tubers from the sprayed rows there was only occasionally one affected with rot. By actual count there were only eight rotten tubers on the four rows of Series II. On the unsprayed rows the loss from rot was about two per ct.

AS SHOWN BY CHEMICAL ANALYSIS.

In the experiment at Geneva in 1902, fifty consecutive hills from a row sprayed seven times and the same number of hills from an adjacent unsprayed row were analyzed in order to determine whether spraying had affected the chemical composition of
the tubers. It was found that the sprayed potatoes contained a larger percentage of dry matter which consisted mostly of starch. (See Bulletin 221, page 254.)

A similar analysis was made in 1903. Fifty hills of potatoes sprayed five times and fifty hills of unsprayed potatoes were selected from the experiment at Geneva and analyzed. Unfortunately, the selection of these hills was neglected until the digging had progressed so far that it was impossible to secure 50 consecutive hills in any of the rows. Instead, it was necessary to take 25 consecutive hills from each of two sprayed rows (Rows 8 and 14) and 25 consecutive hills from each of two unsprayed rows (Rows 3 and 6). Thus the sprayed and unsprayed hills were not taken from adjacent rows. They were taken, however, from the same portion of the field; namely, at the south end, where the blight was least destructive.

The following analysis was made by Mr. F. D. Fuller:

Table VII.—Character and Composition of Sprayed and Unsprayed Potatoes.

Yield and Size of Tubers.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of tubers in 50 hills</th>
<th>Tubers in one hill</th>
<th>Total weight of tubers</th>
<th>Average weight of tubers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Merchantable</td>
<td>Unmerchantable</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Sprayed potatoes.</td>
<td>227</td>
<td>61</td>
<td>288</td>
<td>5.76</td>
</tr>
<tr>
<td>U nsprayed &quot;&quot;</td>
<td>148</td>
<td>58</td>
<td>206</td>
<td>4.12</td>
</tr>
</tbody>
</table>

Composition of Tubers.

<table>
<thead>
<tr>
<th>Lab. No.</th>
<th>Treatment</th>
<th>Water</th>
<th>Dry Matter</th>
<th>Ash</th>
<th>Protein</th>
<th>Nitrogen free compounds</th>
<th>Starch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1544</td>
<td>Sprayed potatoes.</td>
<td>79.65</td>
<td>20.35</td>
<td>.95</td>
<td>1.96</td>
<td>17.44</td>
<td>13.99</td>
</tr>
<tr>
<td>1543</td>
<td>Unsprayed &quot;&quot;</td>
<td>79.70</td>
<td>20.30</td>
<td>.88</td>
<td>2.18</td>
<td>17.24</td>
<td>13.97</td>
</tr>
</tbody>
</table>

As in 1902, the sprayed potatoes yielded more tubers to the hill and of larger average size than the unsprayed; but in chemical composition the difference was so slight as to appear unimportant.
SOME BUSINESS EXPERIMENTS.

OBJECT OF THE EXPERIMENTS.

There are many persons who question the reliability of the results obtained in experiments like the Station ten-year experiments described in this bulletin. They doubt that such results can be obtained in ordinary farm practice. The objections to the experiments are: (1) They are on too small a scale (three-tenths of an acre); (2) the spraying is done more thoroughly than farmers would do it; (3) it is impossible to determine accurately the expense of the spraying; (4) the idea is prevalent that the Station potatoes are given extra good care in order that large yields may be obtained.

These objections were quite fully discussed in Bulletin 221, pages 257–261; but in order to settle the matter and determine the actual profit in spraying potatoes under ordinary farm conditions the following business experiments were made.

PLAN OF THE EXPERIMENTS.

In the spring of 1903 the Station arranged with five farmers in different parts of the State to keep an account of their spraying operations on potatoes. An accurate record was kept of all the expense of the spraying including labor, chemicals and wear on machinery. One or more rows were left unsprayed except that they were treated with poison to protect them against "bugs." In the fall the tubers on such rows were carefully weighed and the yield compared with that of the same number of adjacent sprayed rows. The spraying and all work connected therewith was done by the farmers themselves and in such manner as they thought best. That is to say, these were farmers' business experiments.

THE JAGGER EXPERIMENT.

This experiment was made by H. A. Jagger, Southampton, Long Island. Thirteen acres of potatoes were sprayed four times at a total expense of $50.91 and the yield was thereby increased by 702 bushels which were sold for $351. The net profit on the operation was $300.09, which is at the rate of $23.08 per acre.
The spraying was done with an outfit consisting of an Eclipse No. 2 spray pump mounted in a 100-gallon tank on a two-wheeled cart hauled by one horse (Plate V.). At each passage five rows were sprayed with two nozzles per row. One man did both the pumping and the driving. The original cost of the spraying outfit was $42: Cart, $15; tank, $9; pump, $10; tubing and nozzles, about $8.

Bordeaux mixture (1-to-8½ formula) was applied four times—June 15, 27, July 15 and 21—at the rate of about 47 gallons per acre at each spraying.

In the first three sprayings paris green was added to the bordeaux at the rate of two pounds to 50 gallons.

The thirteen acres consisted of two fields—one containing eight acres and the other five acres. Both fields were on the same kind of soil, sandy loam, fertilized and cultivated in the same way and planted with the same variety, Carman No. 1, which is the most popular variety in that section. The five-acre field was about 80 rods from the water supply but the eight-acre field was nearer.

In the five-acre field one row 453 feet long was left unsprayed.

On this row paris green was applied twice with a Leggett powder gun to prevent injury from "bugs." The yield of marketable tubers on the unsprayed row was 514 pounds which is at the rate of 274 bushels per acre. The adjacent sprayed row yielded 615 pounds which is at the rate of 328 bushels per acre. Thus the increase in yield due to spraying was 54 bushels per acre or a total of 702 bushels on the 13 acres.

The items of expense for spraying 13 acres four times are as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>294 lbs. copper sulphate at 6c</td>
<td>$17.64</td>
</tr>
<tr>
<td>80 &quot; paris green at 18c</td>
<td>$14.40</td>
</tr>
<tr>
<td>1 barrel lime</td>
<td>$1.35</td>
</tr>
<tr>
<td>Repairs on spraying outfit</td>
<td>$1.50</td>
</tr>
<tr>
<td>45 hrs. labor for man at 20c</td>
<td>$9.00</td>
</tr>
<tr>
<td>45 &quot; horse at 10c</td>
<td>$4.50</td>
</tr>
<tr>
<td>Interest on investment ($42) at 6%</td>
<td>$2.52</td>
</tr>
<tr>
<td>Total</td>
<td>$50.91</td>
</tr>
</tbody>
</table>

The average cost per acre of each spraying was 98 cents.
This experiment was conducted throughout by Mr. Jagger. When the fields were visited by one of the writers on August 13 the unsprayed row had already lost about three-fourths of its foliage from late blight, *Phytophthora infestans*. The sprayed portion of the field was still very green and only slightly injured, but Phytophthora was plentiful among the plants. At this time, nearly all unsprayed potato fields in the vicinity were dead and brown. Some farmers who were digging and marketing their crops reported only traces of rot. However, a few days later there was considerable rot. In some fields as much as two-thirds of the crop rotted.

Mr. Jagger reports that there was some rot all over his sprayed fields, but it was much worse on the unsprayed row. It is likely that more thorough spraying would have resulted in a considerably larger yield on the sprayed fields.

**SALISBURY EXPERIMENT NO. I.**

This experiment was made by J. V. Salisbury & Sons, Phelps, N. Y. Ten acres of potatoes were sprayed five times, on the following dates:—July 24, August 8, 26, September 1 and 5. One row 1223 feet long was left unsprayed. The adjacent row on each side of the unsprayed row was sprayed only once; namely, in the first spraying. (See diagram on page 271.)

The spraying was done with a two-horse, power sprayer purchased of the Field Force Pump Co., Elmira, N. Y. The list price is $75.00. (Plate VI.) At each passage six rows were sprayed with one Vermorel nozzle per row. The Bordeaux used was of the 1-to-8 formula. Poison, white arsenic, was used with the Bordeaux only in the first spraying. Paris green was applied to the unsprayed row once, in lime water. The field was about 40 rods from the water supply which was pumped from a well by hand. One man pumped the water and prepared the Bordeaux while another did the spraying.

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9 Arsenite-of-lime paste was prepared from the white arsenic as follows: 10 pounds of white arsenic and 15 pounds of sal soda (common washing soda) were boiled together in 8 gallons of water until dissolved. The resulting solution was used to slake 20 pounds of quick lime, water being added to make a moist paste. Enough of the paste to contain about one pound of the arsenic was used with 50 gallons of Bordeaux.
The unsprayed rows began to show the effects of blight \textit{Phytophthora} about September 5 and by September 9 there was a marked contrast in appearance between the sprayed and unsprayed rows. By September 12 the unsprayed rows could be recognized at a long distance as a brown streak extending clear across the field. At this time the field as a whole was making a fine appearance although toward the south end there was a spot of perhaps one-fourth acre in which blight had already become thoroughly established. All unsprayed fields in the neighborhood were dead and brown. During the following week the contrast between the sprayed and unsprayed rows became more and more conspicuous until about September 19 at which time the unsprayed rows were dead throughout one-half their length and had only one-fourth to one-third their foliage over the other half. On the same date the adjacent sprayed rows were still quite green except toward the south end where they had lost about one-third their foliage.

On September 28 the north half of the field was in almost full foliage and even as late as October 9 some of the plants here were still quite green. This field continued green fully three weeks longer than unsprayed fields in the same neighborhood.

Nevertheless, over the south half the plants were considerably injured by blight and there was, also considerable loss from rot all over the field, being worst on the unsprayed rows.

There was no damage done by early blight, and flea-beetles caused no damage of any importance. "Bugs" were thoroughly controlled both on the sprayed and unsprayed rows by the one application of poison. The soil was a sandy loam. The potatoes were of two varieties, mixed—Carman No. 3 and Rural New Yorker No. 2. They were planted June 8 to 10.

The method by which the increase in yield was determined can be best explained by the use of a diagram as follows:

---

10 Rows 4, 5 and 6 of the diagram on next page. Strictly speaking only Row 5 was an unsprayed row but in this discussion Rows 4 and 6 are also classed as unsprayed rows. The single spraying they received was too early to do them much good.
DIAGRAM SHOWING METHOD OF DETERMINING THE INCREASE IN YIELD IN SALISBURY EXPERIMENT NO. 1.**

Row 1
  " 2
  " 3
  " 4
  " 5
  " 6
  " 7
  " 8
  " 9

{ Sprayed 5 times.
{ Sprayed once.
{ Not sprayed.
{ Sprayed once.
{ Sprayed 5 times.

Since Row 5 was the only one which had not been sprayed at all, its yield should be taken as representing what the yield of the field would have been had there been no spraying done. Rows 4 and 6, although badly blighted, were evidently somewhat benefited by the one spraying they received and remained green a little longer than Row 5. Rows 3 and 7 appeared to suffer a little from being next to the badly blighted Rows 4 and 6. For this reason it was thought unfair to use them as representatives of the sprayed portion of the field. Accordingly, one-half the combined yield of Rows 2 and 8 was decided upon as being the proper basis for comparison with the yield of the unsprayed Row 5 for the correct determination of the increase in yield due to spraying.

Row 2 yielded 793 pounds and Row 8, 773 pounds, the average being 783 pounds; while Row 5 yielded only 466 pounds. Thus the increase in yield due to spraying was 317 pounds per row which is at the rate of 62½ bushels per acre. The yield of the sprayed rows was 154 bushels and 55 pounds per acre and of the unsprayed row 92 bushels and 12 pounds.

**The yields were as follows:
Rows 1 and 3, combined, 1542 lbs. marketable, 43 lbs. culls.
Row 2 793 " " 28 " "
Rows 4 and 6, combined, 1056 " " 67 " "
Row 5 466 " " 43 " "
Rows 7 and 9, combined, 1434 " " 42 " "
Row 8 773 " " 33 " "
Number of rows required to make an acre, 11.872
In order to determine how much Rows 4 and 6 had been benefited by the single spraying given them, the combined yield of these rows was taken and found to be 1056 pounds or 528 pounds each which is greater than the yield of Row 5 by 62 pounds or at the rate of 12 bushels per acre.

In order to determine how much Rows 3 and 7 had been injured by the adjacent blighted Rows 4 and 6 the combined yield of Rows 1 and 3 was compared with the yield of Row 2; and the combined yield of Rows 7 and 9 compared with the yield of Row 8. The combined yield of Rows 1 and 3 was 1542 pounds. Assuming that Row 1 yielded the same as Row 2 the yield of Row 3 must have been 749 pounds or 44 pounds less than the yield of Row 2. Hence, the damage to Row 3 was at the rate of 3½ bushels per acre. Likewise, assuming that the yield of Row 9 was the same as that of Row 8 the yield of Row 7 must have been 661 pounds or 112 pounds less than the yield of Row 8. Hence the damage to Row 7 was at the rate of 22 bushels per acre. These figures are of considerable interest because they show the unfairness of comparing the yield of an unsprayed row with that of an adjacent sprayed row. Such a comparison makes the increase in yield due to spraying appear to be considerably less than it really is.

The total expense of spraying ten acres five times was $40.07 the items being as follows:

3 45 lbs. copper sulphate at 6c ........................................... $ 20.70
5 bu. lime at 35c ............................................................... 1.75
10 lbs. white arsenic at 5½c ............................................... 5.50
30½ hrs. labor for man at 17½c ......................................... 5.33
25 hrs. labor for man at 15c ............................................. 3.75
28½ hrs. labor for team at 17½c ......................................... 4.99
Wear on sprayer ................................................................. 3.00

Total ................................................................................. $40.07

* Some have expressed the opinion that when a single row in a field is left unsprayed "bugs" and flea-beetles leave the sprayed rows and attack the unsprayed row more severely than they would if no spraying were done. Perhaps this sometimes happens, but we have seen no evidence of it. On the contrary, in four of the business experiments it was very noticeable that the unsprayed rows lived longer and suffered less from blight than did unsprayed fields in the same neighborhood. Consequently, we believe that the actual gain from spraying was greater than the figures here given show it to be.
The cost of spraying per acre for each application was 80 cents. The increase in yield due to spraying was $2\frac{1}{2}$ bushels per acre or 625 bushels on ten acres. At the time the potatoes were dug they could have been sold in Phelps at 50 cents per bushel. That is to say, the 625 bushels were worth $312.50. Deducting from this sum the expense of spraying, $40.07 there is left $272.43 which is the net profit on ten acres. This is at the rate of $27.24 per acre.

**SALISBURY EXPERIMENT NO. 2.**

This experiment, also, was conducted by J. V. Salisbury & Sons, Phelps, N. Y. Fourteen acres of potatoes on sandy soil were sprayed five times with the same outfit and in practically the same way as in the preceding experiment. Seven rows 800 feet long were left unsprayed.

The dates of spraying were as follows: July 23, August 5, 18, September 2 and 8. Poison was used only in the first spraying. The unsprayed rows received an application of paris green in lime water at about the same time.

Although a little late blight (*Phytophthora*) was found on the unsprayed rows on August 27 it was not until September 9 that it began to affect seriously the growth of the plants. By that time it had become thoroughly established throughout the whole length of the unsprayed rows, but was much worse in some places than in others. About one-third the distance across the field from the south end the unsprayed rows ran across a strip of soil which was somewhat different from the rest of the field, being moister, darker in color and less sandy. It was here that the vines grew largest and the blight was most destructive. After crossing this strip of black soil the rows ran up a hillside where the soil was light in color and quite sandy. In this region blight

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**Note:** The only differences worth noting are the following: The work was all done by one man. The water used for making the bordeaux was taken from a spring at one side of the field. Sufficient of the arsenite-of-lime paste (see footnote, page 269) to contain about three-fourths pound of white arsenic was used with 50 gallons of bordeaux.

**Note:** The dates given are those on which bordeaux was applied to the rows next the unsprayed rows. The spraying of the whole field was not always completed on these dates.
never made rapid progress although it worked steadily among the plants and did them much damage. However, the contrast between the sprayed and unsprayed rows became very marked here. The unsprayed rows took on a sickly, yellowish color. This condition was quite noticeable September 9 and continued to be prominent throughout the season, being most conspicuous about September 15. A great many leaves were quite yellow. No doubt this yellowing was partly the result of blight, but it could not have been wholly due to that cause. Many of the yellow leaves showed no blemish whatever. Moreover, where the unsprayed rows ran across the black, moist soil there was scarcely any yellow foliage although it was here that blight was most virulent.

But, whatever the cause, spraying corrected the trouble. On September 15 when the unsprayed rows were decidedly yellow the sprayed rows adjacent were dark green with scarcely a yellow leaf to be seen. The contrast was very striking. We have frequently observed that the foliage of sprayed plants is darker green than that of unsprayed plants, but have never before seen the difference so marked. We consider this an exceptionally good example of the stimulating effect which bordeaux mixture is believed to have on potato foliage. Later in the season there was a little yellow foliage among the sprayed plants.

In this field, spraying kept the blight almost completely under control, except on the strip of heavier soil above mentioned and in two other places where a few rows were skipped in one spraying. An examination of this field at any time during the last half of September should have convinced even the most skeptical that spraying, properly managed, will prevent blight. The unsprayed rows were dead and dry while on both sides the sprayed rows were in almost perfect foliage. (Plate VII.) The sprayed plants remained green so long that it was feared their growth would be cut short by frost, but, fortunately, frost held off unusually late. On October 9 it was estimated that on the average about one-half the foliage on the sprayed plants was still green. This late growth was, doubtless, partly the consequence of the late planting, June 16 to 20, but other fields in
the neighborhood planted equally late died nearly a month earlier.

The potatoes were of two varieties, Carman No. 3 and Rural New Yorker No. 2, mixed. There was no early blight, no damage done by flea-beetles, and "bugs" were thoroughly controlled. There was only an occasional rotten tuber even on the unsprayed rows.

The yield of the seven unsprayed rows was 1921 pounds of merchantable tubers which is at the rate of 83 bushels per acre. Seven sprayed rows adjacent yielded 3403 pounds of merchantable tubers or at the rate of 147 bushels per acre. Thus the increase in yield was 64 bushels per acre or 77 per cent. Considering that there was no loss from rot this is a remarkably large increase.

The total expense of spraying the fourteen acres five times was $55.76, the items being as follows:—

<table>
<thead>
<tr>
<th>Items</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>504 lbs. copper sulphate at 6c.</td>
<td>$ 30 24</td>
</tr>
<tr>
<td>8 bushels lime at 35c.</td>
<td>2 80</td>
</tr>
<tr>
<td>12 lbs. white arsenic at 5½c.</td>
<td>66</td>
</tr>
<tr>
<td>55 hrs. labor for man at 17½c</td>
<td>9 63</td>
</tr>
<tr>
<td>47 hrs. labor for team at 17½c</td>
<td>8 23</td>
</tr>
<tr>
<td>Wear on sprayer</td>
<td>4 20</td>
</tr>
</tbody>
</table>

Total .................................. $55 76

The cost of spraying per acre, for each application, was 80 cents.

Since the increase in yield was at the rate of 64 bushels per acre, the total gain due to spraying 14 acres must have been about 896 bushels of potatoes worth $448. Deducting from this sum the expense of spraying, $55.76, there is left $392.24 which is the net profit on 14 acres. This is at the rate of $28.01 per acre.

From the first of September on, these two Salisbury experiments were visited by the writers every three or four days and full notes on them taken. We regard these experiments as the most instructive ones of the whole series. The conditions under which they were made are fairly representative of the conditions prevailing in the potato growing sections of central and western New York. The yields, 92 and 83 bushels per acre (for the
unsprayed rows), are average yields. The sprayer used is one which is upon the market and can be operated by any man of average intelligence. The rate of increase in yield was determined in such a manner that there can be no doubt as to its accuracy and there is good reason to believe that the same rate prevailed throughout the whole field in both experiments. The writers, themselves, measured the test rows and superintended the digging and weighing. Mr. Salisbury's statement of the amount of the expense of the spraying is, likewise, to be relied upon. If it is thought that any proof is needed it is found in the fact that he sprayed potatoes for some of his neighbors at 80 cents per acre and furnished everything.

THE WELCH EXPERIMENT.

This experiment was made by Ed. Welch, Phelps, N. Y. A field of 3½ acres of potatoes was sprayed five times with an old two-horse, six-row power sprayer of the same make as that used in the Salisbury experiments. It was bought second hand in 1902 for $10. One row 1235 feet long was left unsprayed. The dates of spraying were: August 1, 8, 21, September 3 and 11. As "bugs" were at no time sufficiently numerous to do damage no poison was used, not even on the unsprayed row. The bordeaux was of the 1-to-8 formula and the water used in its preparation was obtained from a well about 20 rods distant.

Traces of blight appeared in all parts of the field about September 2. Thereafter it made steady progress among both the sprayed and unsprayed plants, being most destructive to the latter. After about September 15 the unsprayed row was noticeably inferior to the rest of the field and could be readily located even at a considerable distance, but the contrast was never as striking as in either of the Salisbury experiments. This may have been because there was but a single unsprayed row, and the plants on the sprayed rows being large somewhat obscured it. Although the spraying did not by any means wholly prevent the blight it held it in check to such an extent that the life of the plants was prolonged far beyond that of plants in unsprayed fields. Over the central portion of the field the plants still had one-third to one-half their foliage on October 3.
The increase in yield was determined in the same manner as in the Salisbury Experiment No. 1; that is, the yield of the unsprayed row was compared with one-half the combined yield of two sprayed rows, the second row on either side of the unsprayed row. This will be better understood by an examination of the accompanying diagram.

**DIAGRAM SHOWING METHOD OF DETERMINING INCREASE IN YIELD IN THE WELCH EXPERIMENT.**

<table>
<thead>
<tr>
<th>Row</th>
<th>Yield</th>
<th>Culls</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1028 lbs.</td>
<td>86 lbs.</td>
</tr>
<tr>
<td>2</td>
<td>Not weighed.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1006 lbs.</td>
<td>74 lbs.</td>
</tr>
<tr>
<td>4</td>
<td>Not weighed.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>640 lbs.</td>
<td>137 lbs.</td>
</tr>
<tr>
<td>6</td>
<td>Not weighed.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>980 lbs.</td>
<td>82 lbs.</td>
</tr>
<tr>
<td>8</td>
<td>Not weighed.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1003 lbs.</td>
<td>71 lbs.</td>
</tr>
</tbody>
</table>

Sprayed.

Unsprayed.

One-half the combined yield of Rows 3 and 7 equals 993 pounds which makes the yield of the sprayed rows at the rate of 194 bushels and 37 pounds of marketable tubers per acre; while the yield of the unsprayed row was only 640 pounds or at the rate of 118 bushels and 27 pounds per acre. Hence, the increase in yield was at the rate of 76 bushels per acre.

We wished to obtain the yield of Row 4 for comparison with that of Row 3; also the yield of Row 6 for comparison with Row 7. In this way it could have been determined how much Rows 4 and 6 suffered because of their proximity to the blighted Row 5. But Mr. Welch misunderstood our instructions and took the yield of Rows 1 and 9 instead. It is interesting to note that had these rows been selected to represent the sprayed portion of the field the increase in yield would have been 81½ bushels per acre.
The total expense of spraying these 3½ acres five times was $13.43, the items being as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>94 lbs. copper sulphate at 6½c</td>
<td>$6.11</td>
</tr>
<tr>
<td>2 bushels lime</td>
<td>$0.32</td>
</tr>
<tr>
<td>18 hrs. labor man and team</td>
<td>$6.00</td>
</tr>
<tr>
<td>Repairs on outfit</td>
<td>$0.40</td>
</tr>
<tr>
<td>Interest on investment ($10 at 6 per ct.)</td>
<td>$0.60</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$13.43</td>
</tr>
</tbody>
</table>

The cost of spraying per acre for each application was 77 cents.

As the increase in yield was at the rate of 76 bushels per acre, the total gain due to spraying 3½ acres must have been 266 bushels of potatoes worth $133. Deducting the expense of spraying, $13.43, there is left $119.57 which is the net profit on 3½ acres. This is at the rate of $34.16 per acre.

The soil in this field was a gravelly clay loam. The variety of potato was Carman No. 3.

**THE MARTIN EXPERIMENT.**

This experiment was made by T. E. Martin, West Rush, Monroe Co., N.Y., about 13 miles south of Rochester. Mr. Martin believes in light applications made frequently. He sprayed 15¾ acres 16 times and left 2½ acres unsprayed.

The unsprayed 2½ acres yielded 425 bushels or at the rate of 182 bushels per acre. An exact acre (18 rows) of sprayed plants on either side of the unsprayed yielded 260 bushels, while the total yield of the 15¾ acres sprayed was 4293 bushels, which is at the rate of 274 bushels per acre. The increase in yield was therefore, 78 bushels per acre or a total of 1222 bushels on 15¾ acres.

The total expense of the spraying was $96.32, the items being as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>700 lbs. copper sulphate at 5½c</td>
<td>$38.50</td>
</tr>
<tr>
<td>6 bu. lime at 25c</td>
<td>$0.50</td>
</tr>
<tr>
<td>64 lbs. paris green at 14½c</td>
<td>$0.92</td>
</tr>
<tr>
<td>16 days labor for man at $1.50</td>
<td>$24.00</td>
</tr>
<tr>
<td>16 days labor for horse at $1.00</td>
<td>$16.00</td>
</tr>
<tr>
<td>Wear on sprayer</td>
<td>$0.70</td>
</tr>
<tr>
<td></td>
<td>$96.32</td>
</tr>
</tbody>
</table>

Total.
Deducting the expense of spraying, $96.32, from the value of the increase in yield, $611, there is left $514.68 net profit on 15½ acres or $32.85 per acre.

The sprayer used (Plate VIII) was a one-horse, home-made power sprayer made by overhauling an old Peppler sprayer, using the wheels, axle, thills and barrel and adding the following items: Rumsey double acting force pump, $25; sprocket wheels and chains, $10; steam gauge, $1; relief valve, $1.25; six bordeaux nozzles, $3; gas pipe, fittings, etc., $10; labor, $10; making a total of $60.25.

At each passage six rows were sprayed, with one nozzle per row, applying bordeaux mixture at the rate of about 22 gallons per acre. In successive sprayings the rows were gone over in opposite directions and the nozzles adjusted so as to spray the plants from both sides and on top. The bordeaux was of the 1-to-8½ formula. In the first four sprayings paris green was used with the bordeaux at the rate of four pounds to 50 gallons; but in only one of these sprayings, the second, was the entire 15½ acres gone over. On the unsprayed 2½ acres paris green was applied twice, July 8 and 13.

The potatoes were of the variety Sir Walter Raleigh. Water for making the bordeaux was obtained from a well 100 rods distant. The cost per acre for each spraying was 39 cents.

This experiment is of special interest because of the large number of sprayings and because the area left unsprayed is unusually large, 2½ acres. It ought to satisfy those persons who hold that field experiments should be made on acres instead of on plats. The experiment was carried through entirely by Mr. Martin and the figures are given solely on his authority, but the writers have every reason to believe that the facts are correctly stated.

Mr. Martin informs us that he has carried on similar experiments for several years past, always with profitable results.

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14 The bulk of the crop was sold direct from the field at 40 and 45 cents per bushel. In December the price rose to 60 cents per bushel. In order to facilitate comparison the potatoes in the Martin experiment have been valued at 50 cents per bushel as in the other experiments.
THE DOBSON EXPERIMENT.

This experiment was made by Dobson Bros., Charlotte, N. Y., seven miles north of Rochester. The field contained five acres and was planted with three varieties; namely, Michigan Snowflake, Rural New Yorker No. 2 and American Wonder. Two rows, 451 feet long, of each variety were left unsprayed.

The first spraying was made July 21 with bordeaux mixture (1-to-11 formula) and paris green (1/2 pound to 45 gallons). As some of the "bugs" were not killed, a second spraying with bordeaux and paris green was made a few days later. This time, bordeaux of the 1-to-71/2 formula was used and paris green added at the rate of one pound to 45 gallons. The "bugs" were then all killed and there was no further trouble from them. The unsprayed rows were treated with paris green in water, July 22, and the "bugs" all killed.

On September 4 a third spraying with bordeaux alone was given to six rows on either side of the two unsprayed rows of each variety. Thus the field as a whole had but two sprayings while a few rows next the unsprayed rows were sprayed three times.

The spraying was done with a "Planet" double acting pump attached to a 50-gallon barrel mounted on a home-made, two-wheeled cart hauled by one horse (Plate IX). A boy did the driving and pumping while two men held each a nozzle at the end of a lead of hose. The cost of this outfit was about $17. Water was obtained from a well about 60 rods distant.

Strange to say there was scarcely any blight (Phytophthora) in this field until at the very close of the season. In fact, but few fields in the vicinity were affected to any extent. The soil was a rich, sandy loam. There was a rank growth of vines which completely covered the ground although the hills were three feet apart each way. As late as September 24 the plants still had three-fourths of their foliage and it was impossible to distinguish the unsprayed rows. There was no difference whatever between the sprayed and unsprayed plants. However, Dobson Bros. report that just before the plants died there was a marked difference which could be seen at a long distance.
PLATE IX.—SPRAYING POTATOES IN THE DOBSON EXPERIMENT.
PLATE X.—A BADLY BLIGHTED POTATO PLANT.
Plate XI.—Under Surface of Potato Leaf attacked by Late Blight.
PLATE XII.—THE FUNGUS OF POTATO LATE BLIGHT.

Phytophthora infestans.
(After U. S. Dept. Agr.)
Under these conditions no marked increase in yield could be expected. The yields are given in the following table:

**Table VIII.—Yields in the Dobson Experiment.**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Sprayed.</th>
<th></th>
<th>Unsprayed.</th>
<th></th>
<th>Gain per acre due to spraying.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michigan Snowflake</td>
<td>1063 Lbs</td>
<td>300 Bu. lbs.</td>
<td>1015 Lbs</td>
<td>287 Bu. lbs.</td>
<td>13 Bu. lbs.</td>
</tr>
<tr>
<td>Rural New Yorker</td>
<td>81 Lbs</td>
<td>277 Bu. lbs.</td>
<td>975 Lbs</td>
<td>275 Bu. lbs.</td>
<td>1 Bu. lbs.</td>
</tr>
<tr>
<td>American Wonder</td>
<td>1059 Lbs</td>
<td>299 Bu. lbs.</td>
<td>1037 Lbs</td>
<td>293 Bu. lbs.</td>
<td>6 Bu. lbs.</td>
</tr>
</tbody>
</table>

The average yield of the three varieties was 292 bushels and 37 pounds per acre for the sprayed rows and 285 bushels and 27 pounds for the unsprayed rows, making the increase in yield 7 bushels per acre or 35 bushels on the five acres.

In the first spraying bordeaux was applied at the rate of 81 gallons per acre and in the second spraying 108 gallons per acre. Assuming that the whole field had been sprayed three times and that the cost of the third spraying was the same as for the second the expense account would stand as follows:

156 lbs. copper sulphate at 7c. .................................. $10.92
198 " lime .................................................................. 66
102 hrs. labor for man at 15c ....................................... 15.30
51 " labor for boy at 7½c ............................................ 3.83
51 " labor for horse at 10c ........................................... 5.10
16½ lbs. paris green at 15c ........................................... 2.48
Wear on sprayer. ............................................................ 1.71
Total .......................................................................... $40.00

Since the total gain due to spraying was only 35 bushels of potatoes worth $17.50, there was a loss of $22.50 which is at the rate of $4.50 per acre. It should be observed, however, that the expense of spraying was unusually large; namely, $2.67 per acre for each application. In the other business experiments reported in this bulletin the cost per acre for each spraying

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55 Owing to portions of the field being damaged by heavy rains early in the season this average was not maintained throughout the field. The total yield of the five acres was about 1200 bushels,
ranged from 39 to 98 cents. With a reasonably large expense for spraying the Dobson field would have paid expenses.

In the Dobson experiment the spraying was done in a business-like manner, but the trouble lies with the method. It is too slow and requires too much man labor. However, had there been a severe attack of blight it is likely that the very thorough spraying would have given results which would have compared very favorably with those obtained in the other experiments.

THE EXPENSE OF APPLYING PARIS GREEN TO POTATOES.

In some parts of the State, particularly on Long Island, many farmers apply paris green to their potatoes in dry form by means of the Legget Powder Gun.\(^{16}\)

Desiring to learn how much it costs to apply poison in this way the Station made arrangements with W. A. Fleet, Cutchogue, Long Island, to keep an account of the expense on his farm.

It should be stated that Mr. Fleet is a successful potato grower and one who does all of his work in a thorough, business-like manner. He has used the Legget Powder Gun several years and understands its use thoroughly. These statements are made in order that it may be understood that the test reported below is a fair one.

In the season of 1903 Mr. Fleet treated 18 acres of potatoes, eleven acres of early potatoes and seven acres of late ones, with "Green Arsenoid," for "bugs." The poison was applied in dry form, undiluted, at the rate of about two pounds per acre with a Legget Powder Gun. On the early potatoes two applications were sufficient. They were made: 1st June 16–25; 2d July 1–8. On the late potatoes a third application was required; namely, on July 15–20. As to the effectiveness of the treatment Mr. Fleet reports as follows:—"The treatment was not thoroughly effective. 'Bugs' were kept in check so they did not eat the vines much, but were not all killed at any one of the three applications." The expense account is as follows:—

\(^{16}\) Manufactured by Legget & Bro., 301 Pearl St., New York, N. Y.

\(^{17}\) "Green Arsenoid" is a substitute for paris green. Manufactured by the Adler Color & Chemical Works, 100 William St., New York, N. Y. For its chemical analysis see Bulletin 190 of this Station, page 289.
84 pounds "Green Arsenoid" at 13½c. ......................... $11.34
65 hours labor at 15c. ..................................... 9.75

Total ....................................................... $21.09

The expense per acre for each application was 49 cents.
Although "Green Arsenoid" instead of paris green was used in the experiment the results may be accepted as applying equally well to paris green. In poisoning properties "Green Arsenoid" is about equal to paris green and the cost of it is but a little less. At the time of making the arrangements with Mr. Fleet to keep the record we understood that he would use paris green. Mr. Fleet makes no report as to the effect on the foliage. We feel confident that "Green Arsenoid" applied at the rate of two pounds per acre must have injured the foliage. The danger of injuring the foliage is greater with "Green Arsenoid" than with paris green.

SUMMARY OF THE BUSINESS EXPERIMENTS.

The principal features of the six business experiments are shown in the following table:—

TABLE IX.—SHOWING RESULTS OF BUSINESS EXPERIMENTS.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Area sprayed.</th>
<th>Bu. per A.</th>
<th>In-crease in yield per A. Bu.</th>
<th>Total increase in yield</th>
<th>Cost per A. each spraying.</th>
<th>Total Expense of spraying.</th>
<th>Net profit per acre.</th>
<th>Total net profit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jagger</td>
<td>13</td>
<td>54</td>
<td>702</td>
<td>$0.98</td>
<td>$50.91</td>
<td>$23.08</td>
<td>$300.09</td>
<td></td>
</tr>
<tr>
<td>Salisbury 1</td>
<td>10</td>
<td>62½</td>
<td>625</td>
<td>.80</td>
<td>40.07</td>
<td>27.24</td>
<td>272.43</td>
<td></td>
</tr>
<tr>
<td>Salisbury 2</td>
<td>14</td>
<td>64</td>
<td>896</td>
<td>.80</td>
<td>55.76</td>
<td>28.01</td>
<td>392.24</td>
<td></td>
</tr>
<tr>
<td>Welch</td>
<td>3½</td>
<td>76</td>
<td>266</td>
<td>.77</td>
<td>13.43</td>
<td>34.16</td>
<td>119.57</td>
<td></td>
</tr>
<tr>
<td>Martin</td>
<td>15¾</td>
<td>78</td>
<td>1222</td>
<td>.39</td>
<td>96.32</td>
<td>32.85</td>
<td>514.68</td>
<td></td>
</tr>
<tr>
<td>Dobson</td>
<td>5</td>
<td>7</td>
<td>35</td>
<td>2.67</td>
<td>40.00</td>
<td>-4.50</td>
<td>-22.50</td>
<td></td>
</tr>
</tbody>
</table>

Total area sprayed, 61⅔ acres.
Total increase in yield, 3746 bushels.
Average increase in yield per acre, 61.24+ bushels.
Total expense of spraying, $296.49.
Average expense of spraying per acre, $4.84+.
Total net profit, $1576.51.
Average net profit per acre, $25.77+. 
SPRAYING AS CROP INSURANCE.

It is sometimes stated that spraying is, in effect, crop insurance; and since blight is not destructive every season many farmers doubt that it pays to insure in this way. With this idea in mind it is instructive to make calculations like the following:

If, in the Jagger experiment, we subtract from the total expense of the spraying, $50.91, the amount of the probable expense necessary to control "bugs," namely, $18.90, there is left $32.01 which is the actual extra expense of using bordeaux 4 times. Now, if we divide the total net profit, $300.09 by $32.01 we get as a quotient 9+ which is the number of years Mr. Jagger can spray the same area in potatoes without incurring loss even though no increase in yield is obtained during that time.

In the same manner it can be shown that in the Salisbury experiment No. 1 enough clear money was made to insure against loss during the next 7+ years; in the Salisbury experiment No. 2, 7+ years; in the Welch experiment, 8+ years; and in the Martin experiment, 6+ years.

CAUSES OF FAILURE.

Because of the heavy loss from blight in 1902 an unusually large number of farmers sprayed their potatoes in 1903. Some were successful while others failed. Naturally, those who failed wish to know why they failed in order that they may be more successful another season. No doubt many are discouraged and have reached the conclusion that potato spraying is a failure.

There are two common causes of failure: (1) The spraying is not done at the proper time; or (2) it is not done thoroughly. During the past season the blight appeared so suddenly that many were taken unawares and, before they could spray, the plants had already become infected. Some made one or two applications in July when bugs were prevalent and then neglected further spraying until the blight appeared during the last week in August. In most cases where this was done there appeared to be but little benefit from the spraying.

An interesting example came under our own observation. Two
small fields of potatoes on the Station farm were sprayed twice early in the season with bordeaux and paris green and then neglected until the blight had made its appearance on a few leaves here and there all through both fields.

On September 1, alternate strips of six rows in both fields were very thoroughly sprayed with bordeaux mixture. As there was at that time fully nine-tenths of the foliage in perfect condition it was thought that the blight could surely be checked by spraying. However, such was not the case. By September 7 from two-thirds to three-fourths of all the leaflets on the sprayed plants were more or less affected and the unsprayed plants were but a trifle worse. A week later the difference was a little greater, but at no time was it of any importance. When the potatoes were dug it was found that in one field the yield of the sprayed and unsprayed rows was the same; namely, at the rate of 63 bushels per acre. While in the other field the sprayed rows yielded 72 bushels per acre and the unsprayed 73. The area of each field was about two-thirds of an acre, about one-half being sprayed in each case. In this experiment spraying was a flat failure.

The explanation seems to be as follows: For a week preceding the date of spraying the weather had been exceptionally favorable to the spread of blight (Phytophthora). Spores from the affected leaves had been freely scattered over the healthy leaves, germinated and pushed their germ tubes into the tissue of the leaves. Thus at the time of spraying the fungus was already within the leaves out of reach of the fungicide but had not yet made sufficient growth to kill the tissue and cause the appearance of dead, brown spots. In spite of the spraying the fungus continued to spread within the leaves soon killing them. Had the spraying been made a week earlier it is likely that the results would have been much more satisfactory.

As a rule, it is unsafe to postpone spraying until the appearance of blight. Usually the blight becomes thoroughly established in a field before it is observed. In any case it is necessary to act very promptly and there are likely to be unforeseen hindrances such as lack of materials or the sprayer being out of order. Then, too, it often happens, as in 1903, that the outbreak of blight occurs during a period of wet weather when it is almost
impossible to get into the field to spray. The only sure way to
avoid such difficulty is to commence early and spray regularly
at intervals of ten to fourteen days as directed on page 292.

Sometimes, this method may result in slight loss. It appears
that over the greater part of the State during the past season
there was but little good done, so far as the prevention of blight
is concerned, by any spraying made before Aug. 1. The im-
portant sprayings were those made during the last two weeks in
August. However, one or two, and sometimes three, applica-
tions of poison for "bugs" must be made anyway and the extra
expense of applying bordeaux with the poison is but a trifle
which is generally more than repaid by the increased efficiency of
the poison for "bugs," partial protection against flea-beetle
injury, protection against early blight and paris green injury
and by stimulation of the plants. Spraying often results in a
marked increase in yield in seasons when there is no late blight.

When late blight is prevalent the spraying should be done very
thoroughly. During damp, muggy weather in August there
is little danger in over-doing spraying. Many fail because they
are too saving of time and materials at such times.

Besides the two common causes of failure already mentioned
there is another which sometimes leads farmers to believe that
spraying does not prevent blight. We refer to the stem blight,
an obscure disease found on Long Island and in the lower Hud-
son Valley. The leaves of affected plants roll inward and up-
ward exposing the under surface. Soon after, the whole plant
begins to dry up slowly and finally dies prematurely. The stem
is discolored at the surface of the soil and the tubers show brown
streaks in the flesh at the stem end but do not rot. Stem blight
is not prevented by spraying. The cause is unknown.

Failure to get results in potato spraying is sometimes attribu-
ted to the alleged imperfection of bordeaux mixture as a fun-
gicide. Occasionally such erroneous views get into print. To be

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\textsuperscript{18} This does not apply to Long Island.

\textsuperscript{19} For a more complete account of stem blight see Bulletin 101 of this
Station, pp. 83--84.

\textsuperscript{20} Curtis, F. C. Give us a better fungicide. \textit{Rural New Yorker} \textbf{62}: 755.
Oct. 31, 1903. This article was ably answered on page 818 of a later issue
of the same paper.
sure, an easier and more effective method of preventing the ravages of potato blight is to be desired, but the urgent need at the present time is not for a better fungicide. The real need is that farmers shall learn to use bordeaux mixture properly. For spraying potatoes, at least, bordeaux mixture is all right and it is a practical remedy for the average farmer. This is shown by the results of the business experiments recorded in this bulletin and also by the experience of thousands of practical farmers scattered over those portions of the United States in which late blight is destructive.

Much of the agitation for a better fungicide than bordeaux mixture for spraying potatoes comes from people who have some substitute for it to sell. We wish here to state that while there are upon the market several patented fungicides or insecticides and fungicides combined which are recommended for use on potatoes, none of them, so far as we know, is equal to the

21 Notwithstanding all that has been said and written about the preparation and use of bordeaux mixture there is still extant a vast amount of ignorance concerning it. The truth of this is shown by the following letter received at the Station during the past season:—

W. H. Jordan,
Geneva, N. Y.

Dear Sir:—If all farmers have the same trouble with bordeaux mixture I have I don't blame them for being reluctant about its use.

"Last Friday I had the nicest potatoes in my garden of any I have seen. Today they look as though I had sprinkled them with a pail of water and a pound of paris green."

Friday morning I sprinkled them with a flower sprinkler, as a sprayer was not at hand, with bordeaux mixture which I have made as follows: In an old milk can I placed 15 gallons of water. In a cloth flour sack I placed 4 lbs. of quick lime and then put 6 lbs. of blue vitriol on top of that. Then I placed the sack in the water and left it about a week, shaking and stirring when I came near it. The solution looks like the ink I am writing with or soot water.

"For every quart of solution I used two quarts of water when I sprinkled. The vines seem to be burut as if I had used an over-dose of paris green."

"Any information as to where I made a mistake will be sincerely received. Very respectfully yours,"

The only comment we care to make is, that people who will not follow directions have only themselves to blame if they get into trouble.
ordinary, home-made bordeaux mixture and paris green as a preventive of blight and insect attacks.

CONDITION OF THE POTATO CROP IN NEW YORK IN 1903.

The severe spring drought, ending about June 7, delayed planting and made the crop unusually late. In many cases the potatoes did not come up well. However, a subsequent abundance of rain and cool weather soon put the crop in good condition. Except on Long Island there was little trouble from flea-beetles; and "bugs," too, were rather less troublesome than usual. Early blight (Alternaria solani) did no damage anywhere in the State.

On Long Island, the late blight (Phytophthora infestans) seems to have first come to notice about July 10 to 15 and continued active during the remainder of the season, being most virulent about August 7 to 15. In the eastern part of Long Island, particularly, most fields were nearly done growing before the epidemic of August 7 to 15 and consequently the yield was not greatly shortened by the premature death of the plants. Some farmers who dug and marketed their crop before August 15 got good yields and lost but little from rot. During the following week rot set in to such an extent that most buyers refused to take any potatoes for several days. Thus, on the later part of the crop there was much loss from rot variously estimated at from 5 to 75 per ct. in different fields.

Throughout the State late blight was general. Only a few localities escaped its ravages. In most places it was exceedingly virulent, being most destructive to the later planted potatoes. There was some of the disease among early potatoes, but not as much as in 1902. Up to about August 24 there was but little if any damage done to the late potatoes and the prospect for a fair crop was good. Then there came a period of rainy weather and late blight suddenly became exceedingly virulent. Early planted fields were attacked first, but in the end the late planted ones suffered the worst. All through the central and western portions of the State potato fields which should have remained
green until October 1 were entirely dead by September 10 or earlier. In many cases the blight was followed by rot which caused still further loss.

After making a thorough survey of the situation the writers estimate that the loss from late blight (*Phytophthora infestans*) in New York State in the season of 1903 was fifty bushels per acre on an average. Since the area devoted to potatoes in the State is about 396,000 acres\(^2\) and the average price at the digging time was 50 cents per bushel, the total loss sustained by our farmers is almost $10,000,000. A large part of this loss might have been prevented by spraying.

**THE NATURE OF POTATO BLIGHT.**

Farmers use the word blight to indicate almost any injury which causes potato foliage to turn brown and die. Hence, blight may be early blight, stem blight, late blight, flea-beetle injury, paris-green injury, the effects of drought, etc. Lack of space prevents a full discussion of the various forms of blight at the present time. However, a few words on the nature of late blight seem absolutely necessary to a proper understanding of the subject of potato spraying.

It is late blight which is chiefly responsible for the heavy losses on the potato crop in New York during the past two years. Late blight appears during damp, muggy weather in August and September. It first appears on the leaves (usually the lower ones) in the form of small brown spots which rapidly enlarge. In moist weather the margins of the diseased spots are covered, on the under surface, with a fine, frost-like mildew (Plate XI). In dry weather, this mildew may be difficult to detect. In the later stages of the disease affected plants frequently have the appearance shown in Plate X. Under favorable weather conditions a field of potatoes may be almost completely ruined within a few days after the first appearance of the disease.

Contrary to popular opinion, this form of blight is not caused by wet weather. The real cause is a parasitic fungus. Without the fungus there could be no blight of this kind, no matter what

\(^2\)395,640 acres in 1899, according to U. S. census.
the weather conditions might be. Blight is most virulent in wet weather because the blight fungus thrives best and spreads most rapidly in wet weather.

In Plate XII the potato blight fungus, *Phytophthora infestans*, is illustrated. Figure 1 is a cross section of a blighted potato leaf. The branching, tree-like affairs hanging down from the undersurface are the spore-stalks of the fungus. It is these which make up the frosty mildew on the undersurface of affected spots. The egg shaped bodies at the ends of the branches are the spores. When one of these spores falls upon a healthy potato leaf in a drop of water it germinates within a few hours (after the manner shown in Fig. 5) and forces a slender, colorless tube into the tissue of the leaf. Once within the leaf the colorless tube branches and penetrates the leaf in all directions (See Fig. 1), absorbing nourishment from the cells of the leaf and later killing them. As the leaf tissue dies the fungus forms spore-stalks bearing new spores and the life cycle is complete. Usually about four or five days elapse between the germination of the spore and the production of a new crop of spores.

The rot of the tubers which frequently follows an attack of blight is caused by spores which fall upon the ground and are washed down to the tubers by the rain. In some cases the fungus may pass down the stem and the tubers become infected in that way; but this method is the exception rather than the rule.

So far as known, the potato blight fungus has no spores which live over winter. It is believed that the fungus survives the winter in slightly affected tubers. Hence it is advisable to avoid planting tubers which show any signs of disease.

The philosophy of spraying as a preventive of blight and rot in potatoes is this:—The leaves are coated with a substance (bordeaux mixture) which either prevents the germination of the spores or else kills their delicate germ tubes before they can penetrate the leaf tissue. Consequently, the fungus is unable to establish itself in the leaves and there are no spores to fall upon the ground and cause rot.

CONCERNING THE USE OF POISON WITH BORDEAUX MIXTURE IN SPRAYING POTATOES.

In Bulletin 221 the writers advised against the use of paris green alone for "bugs," and recommended the use of bordeaux mixture containing paris green whenever it is necessary to fight insects. The experience of the past season tends to confirm us in this opinion. The extra expense of using bordeaux with the
poison is slight and the benefits are likely to be considerable. (See Bulletin 221, pages 261–262.) In the Fleet experiment (Page 282) the expense of applying “Green Arsenoid” with a Leggett powder gun was 49 cents per acre for each application, while in the Jagger experiment (Page 268) the expense of applying bordeaux and paris green was only 98 cents per acre for each application. About the same quantity of poison per acre (two pounds) was used in both cases and the “Green Arsenoid” cost 4½ cents per pounds less than the paris green. Hence, the actual extra expense of using the bordeaux was only 40 cents per acre. When the poison is applied with a sprayer the difference is merely the cost of the copper sulphate and a little extra labor in preparing the bordeaux.

Our recommendation to use paris green with bordeaux at the rate of one-half to three-fourth of a pound to 50 gallons of bordeaux has been criticised by some farmers who say the quantity of poison is too small. They can not kill the “bugs.” At the Station we have had no difficulty in controlling “bugs” with the amount of paris green named, but our success is due to two things:

1) The application of bordeaux and poison has been made promptly upon the appearance of the “bugs.” This is important, because a young “bug” is much more easily poisoned than the full grown beetle. The younger the “bugs” the more easily they are poisoned.

2) At the Station spraying is usually done very thoroughly, using 100 gallons or more per acre; while farmers mostly use 25 to 50 gallons per acre. In using 100 gallons per acre the paris green would be applied at the rate of one pound per acre; while farmers using the same formula, and applying 25 gallons per acre would make a pound of paris green cover four acres. That is the difficulty. The important point to decide is not how much poison to use with 50 gallons of bordeaux, but, rather, how much poison to apply per acre. Accordingly, the directions for the use of poison have been changed (See page 293).

In this connection it may be mentioned that we think very highly of white arsenic as a poison for “bugs” provided it is used with bordeaux. Its chief advantage is its cheapness. A pound of white arsenic is equal to about two pounds of paris green in poisoning properties and costs only about one-third as much. Hence, it is about one-sixth as expensive as paris green.

It is prepared for use as follows:—Dissolve one pound of white arsenic and four pounds of salsoda (washing soda) in one gallon of water by boiling 15 or 20 minutes. This makes the stock solution which can be bottled and kept until desired for use. For spraying potatoes add two quarts of the stock solution (one-half
pound white arsenic) to the quantity of bordeaux required to
cover an acre. This is equivalent to an application of one pound
of paris green per acre.

In using the white arsenic stock solution with bordeaux mix-
ture prepared by the potassium ferrocyanide test it is always
advisable to add lime a little in excess of the amount required to
satisfy the test in order to prevent the possibility of injuring
the foliage. In our experience it has not injured the foliage in
the least when used with bordeaux. If used in lime water there
must be plenty of lime or the foliage will be injured. White
arsenic was used with entire satisfaction in both of the Salisbury
experiments at Phelps and in the Station experiments at Geneva
and Riverhead.

DIRECTIONS FOR SPRAYING.

In general, commence spraying when the plants are six to
eight inches high and repeat the treatment at intervals of 10 to
14 days in order to keep the plants well covered with bordeaux
throughout the season. During epidemics of blight it may be
necessary to spray as often as once a week. Usually six applica-
tions will be required. The bordeaux should contain six pounds
of copper sulphate to each 50 gallons. Whenever "bugs" or
flea-beetles are plentiful add one pound of paris green or two
quarts of white arsenic stock solution (See p. 292) to the quantity
of bordeaux required to spray an acre.

Thoroughness of application is to be desired at all times, but
is especially important when flea-beetles are numerous or the
weather favorable to blight. Using the same quantity of bor-
deaux, frequent light applications are likely to be more effective
than heavier applications made at long intervals; e. g., when a
horse sprayer having but a single nozzle per row is used, it is
better to go over the plants once a week than to make a double
spraying once in two weeks.

Those who wish to get along with three sprayings should post-
pone the first one until there is danger of injury from "bugs"
or flea-beetles, and then spray thoroughly with bordeaux and
poison. The other two sprayings should likewise be thorough
and applied at such times as to keep the foliage protected as much
as possible during the remainder of the season. Very satisfac-
tory results can be obtained from three thorough sprayings.

A single spraying is better than none and will usually be pro-
fitable, but more are better. It is unsafe to postpone spraying
until blight appears. Except, perhaps, on small areas, it does
not pay to apply poison alone for "bugs." When it is necessary
to fight insects use bordeaux mixture and paris green together.