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SPRAYING POTATOES ON LONG ISLAND IN THE SEASON OF 1896.

F. C. STEWART.

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*Connected with Second Judicial Department Branch Station.
†Connected with Fertilizer Control.
New York Agricultural Experiment Station,
Geneva, N. Y., April 5, 1897.

Hon. Charles A. Wieting,
Commissioner of Agriculture, Albany, N. Y.

Sir:—I have the honor to submit for publication under the laws of 1896, Chapter 231, the results of experiments made by the Station in spraying potatoes on Long Island in the season of 1896. The season was a very favorable one to test the utility of the application of fungicides under ordinary conditions as the potatoes were unusually free from disease. The results indicate that the grower will do well to spray his potato crop every year, not only as a means of insurance against severe attacks of disease but because it will be directly profitable.

W. H. Jordan,
Director.
SPRAYING POTATOES ON LONG ISLAND IN THE SEASON OF 1896.

F. C. STEWART.

SUMMARY.

(1) Potatoes on Long Island in 1896 were unusually free from disease. In spite of this fact, spraying five times with Bordeaux mixture increased the yield on Victor Rose 4 3-4 bu., on White Elephant 60 1-2 bu., on Green Mountain 62 bu., on Defender 16 bu. and on Late Blush 28 bu. per acre. Pages 238-245, 251.

(2) The total expense of spraying 8.58 acres of potatoes five times, including all labor and cost of chemicals and an allowance for the wear of machinery, was $34.25, or $4 per acre. Pages 241-2.

(3) The expense of applying Paris green twice to 1.09 acres of potatoes, by means of the Leggett powder-gun, was $1.65, or $1.51 per acre. Pages 242-3.

(4) Comparing the value of the increase in yield due to spraying, with the outlay required to produce that increase, it was found that spraying had been profitable on all varieties except Victor Rose. On the variety Green Mountain there was a net profit of $13 per acre, allowing potatoes to be worth 25 cents per bushel. Spraying, being profitable in such a season as 1896, must be profitable in almost any season on Long Island. Page 244.

(5) Fungiroid, applied dry, was found to be so much inferior to the wet Bordeaux mixture that its use as a substitute for Bordeaux mixture is not to be recommended. Page 253.
(6) The "Lion Brand" Bordeaux mixture, likewise, proved to be of practically no value. Page 253.

(7) Bordeaux mixture (1-to-7 formula) used without any Paris green, gave considerable protection against insects but not enough to warrant the recommendation of its use. Paris green should always be added to the Bordeaux mixture whenever either flea-beetles or Colorado potato-beetles are numerous. Page 253.

(8) It appears that three applications of Bordeaux mixture are not sufficient for potatoes on Long Island. In the early part of the season it is necessary to fight flea-beetles and Colorado beetles, in midsummer the early blight must be kept in check and in the latter part of the season late blight and flea-beetles make their appearance. The plants need protection throughout the season. Pages 252-3.

(9) 1-to-11 Bordeaux gave slightly better results than 1-to-7 Bordeaux. As a repellant of insects the weak mixture seems to be fully as effective as the stronger mixture. Had blight been prevalent the results might have been different. The use of the weak mixture cannot be recommended without further trial. Page 252.

(10) Plants sprayed five times with Bordeaux mixture at the rate of 100 gallons per acre, yielded in one case 15 bushels per acre and in another case 27 bushels per acre more than plants sprayed at the rate of 50 gallons per acre. Pages 254-5.

(11) A trial of the Hudson Special Bordeaux Sprayer showed it to be an efficient sprayer for applying Bordeaux mixture to potatoes. Pages 256-7.
INTRODUCTION.

It is a well known fact that the ravages of the late blight or rot blight (*Phytophthora infestans*) of the potato can be prevented by spraying the plants with Bordeaux mixture. Many carefully conducted experiments have been made, both in this country and in Europe, and in almost every one of these experiments the late blight and potato rot have been successfully controlled by spraying. The amount of evidence is so great that we are obliged to accept it as an established fact that late blight can be prevented by spraying.

The disease makes its appearance in midsummer during warm, moist weather and rapidly destroys the plants, whole fields sometimes being ruined in the space of three or four days. At digging time many of the tubers are found to be rotten. Spraying should be commenced before the disease makes its appearance and two or three applications made at intervals of about two weeks. In cases where the disease has been severe this treatment has sometimes saved almost an entire crop at an expense of two or three dollars per acre which shows that, at times, spraying is exceedingly profitable. It is quite generally conceded that it will pay to spray potatoes in those seasons in which late blight occurs.

The late blight, however, does not occur every season. In some portions of the United States it never occurs. On Long Island it probably occurs destructively about one year in four on the average. Now, spraying is preventive, not curative, and so must be commenced before it is known whether the disease will appear. Accordingly, farmers have come to look upon spraying as a form of insurance, and some have raised the question, “Can we not better afford to lose a crop occasionally than to bear the expense of spraying every season?” Those who ask this question assume that spraying is of no value except to prevent the late blight. But that is not true; spraying benefits the potato plant in other ways:

1. Spraying protects it against the attacks of early blight (*Macrosorium solani*), a disease which attacks the leaves, produc-
ing circular or elliptical, dead, brittle spots which are marked with dark colored rings arranged concentrically, like the rings on the ball of the thumb. This disease is not as conspicuous as the late blight but, on the whole, is perhaps fully as destructive since it is more widely distributed and occurs to some extent every season.

(2) Spraying, if done thoroughly, will prevent the greater part of the damage done by flea-beetles (*Crepidodera (Epitrix) cucumeris*).

(3) The plants can be more completely protected against the attacks of Colorado potato-beetles (*Doryphora decemlineata*), than is possible by any method in which Paris green is used alone.

(4) The danger of injury to the foliage from Paris green poisoning is avoided.

(5) Some of the best authorities on the spraying of plants hold that Bordeaux mixture has a beneficial influence on potato foliage even when no insects or diseases are present. The nature of this influence has not yet been satisfactorily explained.

All of the above-mentioned advantages of spraying must be taken into consideration when discussing the question, Will it pay to spray every season?

In most of the recorded experiments on potato spraying, the late blight has been an important factor, and hence these experiments do not furnish a complete answer to the present question. It is necessary to know not only the benefit to be derived from spraying in seasons when late blight is prevalent, but also the benefit to be derived from spraying in seasons when there is no late blight. Fortunately, the conditions have been such that our experiments on Long Island during the past two seasons have thrown considerable light on this very point.

**SPRAYING EXPERIMENT AT FLORAL PARK.**

In 1895 we made a spraying experiment* at Floral Park, Long Island. A field of potatoes containing four and one-half acres was divided into three equal plots. One plot was sprayed five times with Bordeaux mixture, one plot was sprayed three times with Bordeaux mixture and the remaining plot was not sprayed.

*For the details of this experiment see N. Y. Agri. Exp. Sta. Bul. No. 101, pp. 73-76.
With the exception of spraying, the three plots were treated as nearly alike as was possible in every respect. The Colorado potato beetles were kept under control by the use of Paris green. On the sprayed plots the Paris green was applied with the Bordeaux mixture in the first two applications. On the unsprayed plot the same quantity of Paris green was used and was applied in water by means of the spraying machine at the same time the sprayed plots were treated the first two times.

Throughout the entire season there was no trace of late blight, even on the unsprayed plot, and so it might be thought that our spraying had been unnecessary. But the early blight had been prevalent and there had also been some flea-beetles on the unsprayed plot. Spraying with Bordeaux mixture had prevented these enemies from doing much damage to the sprayed plots and as a consequence these plots gave a considerably larger yield than the unsprayed plot. The plot sprayed three times yielded 52 bushels of merchantable tubers per acre more than the unsprayed plot, and the plot which had been sprayed five times yielded 62 bushels per acre more than the unsprayed plot. No record was kept of the expense of the spraying but there was certainly considerable profit.

FIRST SPRAYING EXPERIMENT AT EAST WILLISTON.

There being a demand for some definite information as to the expense of spraying potatoes on Long Island, the Station, in 1896, undertook an experiment along this line. The season was remarkably favorable for the potato crop, as very little disease of any kind appeared. This fact made our results exceptionally valuable since they show what spraying will do for potato plants which are apparently healthy.

From Mr. R. H. Robbins, we obtained the privilege of using for the experiment a potato field containing about nine and two-thirds acres on his farm near East Williston, Long Island. The field was in the form of a parallelogram, 48 rods long and about 32 rods wide, the rows running the short way. The soil was practically uniform and had been fertilized alike all over the field. In 1895 the entire field was planted to cabbage. In 1896 four varieties of potatoes were planted—64 rows of Victor Rose, 93 rows of White Elephant, 53 rows of Green Mountain and 73
PLATE I.—The spraying outfit used in the experiment at East Williston.
rows of Defender. Care was taken that the field should receive
the same cultivation throughout.

Each variety was divided into two plots, one of which was
sprayed with Bordeaux mixture five times according to the
approved method, and the other was not treated at all, except that
Paris green was applied twice with Leggett’s powder-gun accord-
ing to the common practice of Long Island farmers. At the close
of the season the potatoes on these two plots were dug and
weighed separately.

The accompanying diagram shows the relative size and posi-
tion of the sprayed and unsprayed portions of the field.

*How the spraying was done.*—It being desired to ascertain the
expense of spraying potatoes as it should be practiced by the
average grower of late potatoes on Long Island, every part of the
work was put upon a practical basis. All of the methods used
were such as we would recommend for actual farm practice. We
sprayed five times with Bordeaux mixture, 1-to-8 formula,
commencing when the plants were about six inches high and
repeating the treatment at intervals of about two weeks. When-
ever Colorado potato-beetles or flea-beetles became numerous,
Paris green was added to the Bordeaux mixture at the rate of
three-fourths of a pound of Paris green to 50 gallons of the
Bordeaux mixture. The copper sulphate was purchased directly
from the manufacturer in New York in quantity (450-pound bal-
rel) at 4½ cts. per pound. The spraying outfit used is shown in
Plate I. It consisted of an Eclipse No. 2 spray-pump mounted
in a 70-gallon barrel which was put on a stout two-wheeled cart having wheels five feet eight inches apart and hauled by one
horse. By means of a rubber hose the spray-pump communicated
with a three-fourths-inch iron pipe to which were attached eight
Deming-Vermorel nozzles, arranged in such a manner that each of

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2 The dates of spraying were June 4, June 19, July 2, July 17 and July 31.


4 The cart and barrel were obtained from a Callister Paris green sprinkler, manufactured and sold by Thomas Callister, Queens, N. Y. Many Long Island farmers are familiar with this sprinkler. An ordinary 50-gallon barrel will answer the purpose just as well except that it will require filling oftener. Any stout two-wheeled cart having a tread of about six feet can be used. A two-wheeled dump-cart will answer the purpose.
<table>
<thead>
<tr>
<th>Variety</th>
<th>Rows</th>
<th>Treatment</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victor Rose</td>
<td>56</td>
<td>Sprayed</td>
<td>1.9382</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Victor Rose</td>
<td>8</td>
<td>Not sprayed</td>
<td>0.2758</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Elephant</td>
<td>84</td>
<td>Sprayed</td>
<td>2.8817</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Elephant</td>
<td>9</td>
<td>Not sprayed</td>
<td>0.3073</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green Mountain</td>
<td>48</td>
<td>Sprayed</td>
<td>1.6318</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green Mountain</td>
<td>5</td>
<td>Not sprayed</td>
<td>0.1694</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defender</td>
<td>63</td>
<td>Sprayed</td>
<td>2.1261</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defender</td>
<td>10</td>
<td>Not sprayed</td>
<td>0.3358</td>
</tr>
</tbody>
</table>

*Diagram of Experiment Field at East Williston.*
four rows received the spray from two nozzles. Thus, four rows were sprayed at each passage. One man (an ordinary farm laborer) worked the pump and did the driving. This same man prepared the Bordeaux mixture and did all work connected with the spraying. The water used in the Bordeaux mixture was obtained at a farm-house which was 40 rods from the nearest point of the field. Therefore, it was necessary to haul the water from 40 to 88 rods. The Bordeaux mixture was prepared at the farm-house and taken to the field in the spray-barrel.

**Expense of the spraying.**—The items of expense are as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>240 lbs. copper sulphate at 4½ cts. per pound</td>
<td>$10.80</td>
</tr>
<tr>
<td>Freight on 240 lbs. copper sulphate</td>
<td>0.25</td>
</tr>
<tr>
<td>1 barrel unslaked lime</td>
<td>1.40</td>
</tr>
<tr>
<td>Carting sulphate and lime from railroad station</td>
<td>0.50</td>
</tr>
<tr>
<td>Potassium ferrocyanide</td>
<td>0.10</td>
</tr>
<tr>
<td>25 lbs. Paris green at 20 cts. per pound</td>
<td>5.00</td>
</tr>
<tr>
<td>44 hrs. labor for man at 15 cts. per hour</td>
<td>6.60</td>
</tr>
<tr>
<td>44 hrs. labor for horse at 15 cts. per hour</td>
<td>6.60</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$31.25</strong></td>
</tr>
</tbody>
</table>

This $31.25 covers all labor and cost of chemicals but does not include any allowance for the wear of machinery. The latter, however, is a part of the necessary expense of spraying and must be taken into consideration; but the amount can only be estimated. Considering that the first cost of the spraying outfit, exclusive of the cart, was less then $25, and that it was in use only about one-tenth of the time it might have been used, it would seem that $3 is sufficient to allow for the wear of the machine. Three dollars added to $31.25 (cost of labor and chemicals) makes the total expense of spraying 8.58 acres, $34.25; or the total expense of spraying one acre five times, $4; or the total expense per acre for each spraying, 80 cts.

Any farmer can spray potatoes as cheaply as this, provided he goes about it in the right way and is not obliged to haul water too far. The ease with which water can be obtained has an important bearing on the expense of spraying. Where water can be obtained easily and does not require hauling more than a few rods, spraying can be done for less than $4 per acre. In our experiment the water was pumped by hand and hauled from 40 to 88 rods, which consumed considerable time. We have also
placed the value of labor, for both man and horse, a trifle high. Thirty cents per hour or three dollars per day for a man and horse is more than they will cost the average farmer.

The total quantity of Bordeaux mixture used in the experiment was 1,975 gallons, or 46 gallons per acre for each application. The quantity of Bordeaux mixture required depends largely upon the kind of nozzle used. The nozzle should throw a mist-like spray, the finer the better. Nozzles which throw a coarse spray waste the Bordeaux mixture. Deming-Vermorel nozzles were used in the experiment.

_Treatment of the unsprayed plots._—As previously stated, a few rows of each variety were left unsprayed in order that the benefit from spraying might be definitely determined by comparing the yield of the sprayed plot with the yield of the unsprayed plot. These unsprayed plots were treated as the average farmer would treat his crop.

On Long Island it has become very popular to combat the Colorado potato-beetles with Paris green applied dry by means of Leggett's powder-gun. The Paris green is diluted with a considerable quantity of flour or air-slaked lime, preferably the latter, since the lime prevents the Paris green from "burning" the foliage. So we planned to treat the unsprayed or check plots in this manner.

The owner of the field was asked to notify us when he thought it was necessary to begin fighting the Colorado potato-beetles. On June 26 he notified us that the potato-beetles were beginning to do damage to the unsprayed plots and should be poisoned. The same day we applied Paris green with Leggett's powder-gun under what we considered favorable circumstances. On the 1.09 acres there were used 1.5 pounds of Paris green mixed with 13 pounds of air-slaked lime. There was very little wind and the morning had been misty so that the foliage was wet. The Paris green and lime adhered well to the foliage and most of the beetles were killed.

On July 11 it was thought necessary to apply Paris green again. This time three pounds of Paris green were applied with lime in the same manner as before. The day, however, was not so suitable for the work. There was no wind but the foliage was dry,
Most of the beetles were killed and they did not again become sufficiently numerous to seem to require another treatment.

The expense of treating the 1.09 acres with Paris green was as follows:—

\[
\begin{align*}
4\frac{1}{2} \text{ lbs. Paris green at 20 cts. per pound} & \quad \text{\$0.90} \\
5 \text{ hrs. labor at 15 cts. per hour} & \quad \text{\$0.75}
\end{align*}
\]

Total \text{\$1.65}

This makes the expense per acre \text{\$1.51}, which is undoubtedly somewhat greater than it is in ordinary farm practice. The powder-gun was rusty and did not work well, which resulted in a loss of time and waste of Paris green.

The Results.—In the case of each of the four varieties the sprayed plot and the unsprayed plot were dug and weighed separately. The product of each plot was also divided into "merchantable tubers" and "culls," the latter class including not only the small tubers but also those which had been mutilated by the potato digger. The accompanying table presents the results in a condensed form:

**Effect of Spraying with Bordeaux Mixture Upon Yield of Potatoes.**

<table>
<thead>
<tr>
<th>Variety and treatment.</th>
<th>Yield per acre.</th>
<th>Increase in total yield per acre due to spraying.</th>
<th>Increase in yield of merchantable tubers per acre due to spraying.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Merchantable</td>
<td>Culls.</td>
<td>Total.</td>
</tr>
<tr>
<td>Victor Rose</td>
<td>167</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>{Sprayed}</td>
<td>162</td>
<td>30</td>
<td>9</td>
</tr>
<tr>
<td>{Unsprayed}</td>
<td>185</td>
<td>21</td>
<td>14</td>
</tr>
<tr>
<td>White Elephant</td>
<td>124</td>
<td>47</td>
<td>11</td>
</tr>
<tr>
<td>{Sprayed}</td>
<td>253</td>
<td>38</td>
<td>13</td>
</tr>
<tr>
<td>{Unsprayed}</td>
<td>191</td>
<td>33</td>
<td>11</td>
</tr>
<tr>
<td>Green Mountain</td>
<td>194</td>
<td>29</td>
<td>8</td>
</tr>
<tr>
<td>{Sprayed}</td>
<td>178</td>
<td>23</td>
<td>5</td>
</tr>
<tr>
<td>{Unsprayed}</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No trace of late blight appeared in any part of the field. There was some early blight on the unsprayed plots but not as much as usual. The average observer would have said that the
plants on the unsprayed plots were free from disease throughout the season and that it would certainly have been a waste of labor to spray them. Flea-beetles and Colorado potato-beetles were abundant.

In spite of the fact that the plants appeared to be free from disease of all kinds, spraying increased the yield sufficiently to pay all of the expense of spraying and a fair profit besides. The fact must not be overlooked that had these potatoes not been sprayed, Paris green must have been applied to them with a powder-gun or in some other way to keep the Colorado potato-beetles in check. Practically speaking then, the expense of spraying is not $4 per acre but $4 minus the expense of applying Paris green alone, which, in the experiment, was $1.51. We admit that $1.51 is probably high but in the absence of more accurate information we are obliged to use this sum. The difference between $4 and $1.51 is $2.49 which is the amount of extra expense per acre caused by spraying.

By consulting the table it may be seen that spraying increased the yield of merchantable tubers per acre on the four varieties as follows:

<table>
<thead>
<tr>
<th>Variety</th>
<th>Yield</th>
<th>Value at 25 cts. per lb.</th>
<th>Cost of spraying</th>
<th>Total Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victor Rose</td>
<td>4 bu. 47 lbs.</td>
<td>Value at 25 cts. per bu. $1.19</td>
<td>$1.30</td>
<td>$1.20</td>
</tr>
<tr>
<td>White Elephant</td>
<td>60 lb.</td>
<td>Value at 25 cts. per lb. $1.19</td>
<td>$1.34</td>
<td>$1.42</td>
</tr>
<tr>
<td>Green Mountain</td>
<td>52 lb.</td>
<td>Value at 25 cts. per lb. $1.19</td>
<td>$1.52</td>
<td>$1.63</td>
</tr>
<tr>
<td>Defender</td>
<td>16 lb.</td>
<td>Value at 25 cts. per lb. $1.19</td>
<td>$4.02</td>
<td>$4.14</td>
</tr>
</tbody>
</table>

Comparing the values in the last column with $2.49, the expense of producing them, it is seen that:

- Spraying Victor Rose resulted in a loss of $1.30 per acre.
- " White Elephant " profit of 12.65 "
- " Green Mountain " " 13.03 "
- " Defender " " 1.53 "

Even if the comparison is made with $4, the total expense of spraying, there will still be a profit on all the varieties except Victor Rose—$2.81 loss on Victor Rose, $11.14 profit on White Elephant, $11.52 profit on Green Mountain and 2 cts. profit on Defender.

The results of this experiment tend to show that it will pay to spray potatoes on Long Island every season; for if it has been profitable the past season it will be profitable any season. The season of 1896 was certainly an unusually favorable one for pota-
Toes on Long Island. It is rare that potato plants are so generally free from the various blights.

THE REQUISITES OF A POTATO SPRAYING EXPERIMENT.

The spraying of potatoes has never been practiced to any great extent on Long Island. Last year several farmers tried it for the first time and on account of the lack of blight they failed to obtain the striking results which they had expected. They saw no marked contrast between their fields which had been sprayed and their neighbors' fields which had not been sprayed. In some cases the unsprayed fields made the better appearance. Some of the more careful ones took the precaution to leave an unsprayed strip through the center or along one side of the sprayed field in order to make the test a fair one. They who did this must have observed a difference between the sprayed and unsprayed plants, but probably considered the difference so slight as to be of no practical importance. Had they completed the experiment by carefully measuring the land and measuring the potatoes on the sprayed and unsprayed portions of the field they would, most likely, have been astonished. A difference of from 15 to 20 bushels per acre can scarcely be detected while the crop is growing or even after the tubers have been thrown out by the potato digger, and yet this quantity is ordinarily sufficient to pay the expense of spraying.

To those persons who doubt that spraying pays, we suggest that they give it a fair test. A fair test requires that care be taken to avoid all unnecessary expense and that the sprayed and unsprayed plants shall be under practically the same conditions. They must be of the same variety, planted at the same time, in the same manner, on the same kind of soil, treated with the same kind and quantity of fertilizer and given the same cultivation. The spraying must be properly done, the land accurately measured and the crop weighed. Failure to comply with any one of these conditions makes the test an unfair one.

THE PHILOSOPHY OF SPRAYING.

It is believed that, in some unexplained way, the Bordeaux mixture has a direct beneficial influence on potato foliage, in addition to its value as a fungicide and repellent to insects. Its
chief value, however, lies in the protection which it affords the leaves against the attacks of parasitic fungi and insects. The leaves of the potato plant are very essential organs and it is of the greatest importance that they should be perfect in order that they may do their work properly. The inorganic food substances which the plant absorbs from the soil through its roots are transferred to the leaves and by them assimilated, or in other words; transformed into starch and certain other organic substances which pass down the stem and are stored up in the tubers. The size and quality of the tubers are, therefore, directly dependent upon the activity of the leaves. If portions of the leaves are eaten away by insects or destroyed by disease their capacity for assimilation is lessened and the tubers are correspondingly smaller.

The truth of this is recognized when there is great destruction of foliage such as is caused by a severe attack of late blight or by hordes of Colorado potato-beetles, but it seems certain that the amount of damage done by leaf-eating insects and parasitic fungi is greatly underestimated. This is proven by the results of the spraying experiment reported in the previous pages. In that case, spraying increased the yield on one variety by the amount of 62 bushels per acre, chiefly by protecting the leaves in the following three ways: (1) from the apparently slight injury of the early blight fungus; (2) by affording partial protection from the injury caused by flea-beetles; and (3) by preventing the attacks of Colorado potato-beetles more thoroughly than could be done by means of Paris green applied with a powder-gun. No one of these three kinds of injury appeared great but the sum of the three was sufficient to make spraying very profitable.

The fungi which cause the diseases early blight and late blight, propagate themselves by means of minute spores which may be carried from plant to plant by the wind. When one of these spores falls upon a potato leaf and finds there a drop of dew or other moisture it germinates and grows into the leaf, producing a new disease-spot. If the leaf is covered with a thin coating of Bordeaux mixture the spore is unable to germinate and in this way spraying prevents fungous diseases. It is evident that any leaf which has none of the Bordeaux mixture will not be protected.

Bordeaux mixture will not kill either flea-beetles or Colorado
potato-beetles, but it is very distasteful to them. They will not feed upon leaves covered with Bordeaux mixture if they can avoid it; and when Paris green is added to the Bordeaux mixture we have the best known remedy for both these insects. The Bordeaux mixture, being very adhesive, holds the Paris green on the leaves through quite heavy rains which would wash off Paris green applied in any other way. For flea-beetles, Paris green applied by the ordinary methods seems to be almost without avail. It is a mistaken notion, however, that Paris green is not poisonous to flea-beetles. It certainly will kill them if they eat it, and it is probable that a goodly number of them are actually killed by the Paris green applied in the ordinary way for potato-beetles. But flea-beetles are very cautious insects and shun the poison. If the Paris green is mixed with Bordeaux mixture and applied in the form of a fine spray, the poison will reach nearly every leaf and stick there for a long time, keeping the flea-beetles at bay.

From this discussion it will be seen that the degree of success attained in fighting flea-beetles by spraying depends upon the thoroughness with which the spraying is done. Leaves which are kept well covered with Bordeaux mixture and Paris green will suffer very little from flea-beetle attacks. Such leaves will suffer slightly from attacks made on the undersides, for flea-beetles feed to some extent from the under sides of the leaves where it is difficult to reach them with Bordeaux mixture. But all leaves which do not receive the Bordeaux mixture will be attacked by flea-beetles and also by fungi. In spraying, then, care must be taken that each and every leaf receives a little of the Bordeaux mixture. With a knapsack sprayer this is easily accomplished. There is no danger of getting on too much—the more the better. Where the spraying is done with stationary nozzles it is more difficult to reach all of the leaves. Experience has shown that one nozzle per row (no matter of what kind the nozzle may be) is insufficient. Two good nozzles per row will cover the foliage fairly well.

While it is impossible to state with accuracy what degree of protection against flea-beetles will be afforded by Bordeaux mixture and Paris green applied every two weeks by means of two stationary nozzles per row, observation leads us to estimate
it at from 25 to 50 per cent.; that is, plants sprayed in this way would be injured by flea-beetles from one-half to three-fourths as much as plants not sprayed. In view of the results of the experiment reported on page 255 of this bulletin we are of the opinion that it will pay to use three nozzles per row in the last two sprayings.

SECOND SPRAYING EXPERIMENT AT EAST WILLISTON.

The following spraying experiment was made in the season of 1896 on a farm managed by C. Burkard and located near East Williston, N. Y.

*Objects of the experiment.*—The experiment was designed to furnish information on several points of interest in regard to the spraying of potatoes.

During the past two years the Station has received numerous inquiries concerning the value of the so-called dry Bordeaux mixture patented under the name "Fungiroid." This is manufactured and sold by Leggett & Brother, 301 Pearl St., New York. It is claimed to be a remedy for potato blight and some other fungous diseases and is to be applied in dry form with a powder-gun sold by the same firm. The powder-gun is much used by Long Island farmers for applying Paris green to potatoes and the question is often asked, Will not the Fungiroid and Paris green applied together with the powder-gun produce as good results as the wet Bordeaux mixture applied with a spraying machine? An answer to this question was one of the objects of the experiment.

James A. Blanchard, 4 and 6 Gold St., New York, has patented and placed upon the market a concentrated form of Bordeaux mixture which is known as the "Lion Brand" Bordeaux mixture. It is sold in tin cans containing one gallon of a thick, slate colored liquid. This quantity is to be added to 49 gallons of water and applied with a spraying machine in the ordinary way. This mixture also was tested in the experiment.

In some sections of the United States three applications of Bordeaux mixture to potatoes are considered sufficient. In other sections it seems necessary to make five applications. In our experiment at Floral Park, in 1895, one plot was sprayed three
times and another five times, the first three applications on the
two plots being made on the same dates. The plot sprayed five
times yielded 10 bushels per acre more than the plot sprayed three
times. It was thought that the three sprayings might have given
better results if they had been made at sufficiently long intervals
to cover the entire season of growth. It was planned to test this
in the experiment.

The Bordeaux mixture used for spraying orchards and vine-
yards is made after the 1-to-11 formula, in which 1 pound of cop-
per sulphate is required to make 11 gallons of Bordeaux mixture.
But for spraying potatoes a more concentrated form of Bordeaux
mixture has generally been used; namely, Bordeaux mixture
made after the 1 to 7 formula, in which 1 pound of copper sulphate
is required to make 7 gallons. The weaker mixture is, of course,
the cheaper and consequently the more desirable to use provided
it is equally efficient. To determine the relative efficiency of
these two strengths of Bordeaux mixture was one of the objects
of the experiment.

In the experiment at Floral Park, in 1895, it was observed that
Colorado potato-beetles shunned plants which had been sprayed
with Bordeaux mixture containing no Paris green. This sug-
gested the idea that perhaps Paris green might be dispensed with
and the Bordeaux mixture alone used for both "bugs" and
blight. The experiment was planned to test the value of Bor-
deaux mixture used without Paris green.

Plan of the experiment.—In an experiment in which the char-
acter of the soil is an important factor, long narrow plots are
likely to give more reliable results than square plots or plots in
which the length and breadth are nearly equal. The narrower
the plots the less is the liability to error arising from non-unii-
formity of soil. The experiment under consideration was so
planned that differences in soil conditions were practically eli-
minated and this adds much to the value of the results.

The experiment included 14 rows, 920 feet or nearly 56 rods in
length, of the variety Late Blush.

The rows were numbered consecutively and two separated rows
received similar treatment in each case.

Rows 1 and 8 were treated 5 times with Fungioiroid and Paris green, half and half, applied dry with a Leggett powder-gun according to the directions given on the can.  

Rows 2 and 9 were treated 5 times with Paris green in lime water. The lime water was used to prevent the free arsenious acid in the Paris green from injuring the foliage.

Rows 3 and 10 were sprayed 5 times—the first time with Paris green in lime water the same as was used on Rows 2 and 9, and the last four times with "Lion Brand" Bordeaux mixture and Paris green.

Rows 4 and 11 were sprayed 4 times with Bordeaux mixture (1-to-7 formula) and Paris green. It was the original intention to spray these rows only three times but it was found absolutely necessary to make a fourth application.

Rows 5 and 12 were sprayed 5 times with Bordeaux mixture (1-to-7 formula) and Paris green.

Rows 6 and 13 were sprayed 5 times with Bordeaux mixture (1-to-7 formula) alone.

Rows 7 and 14 were sprayed 5 times with Bordeaux mixture (1-to-11 formula) and Paris green.

The several applications were made to all 14 rows on the same dates; namely, June 11, June 26, July 10, July 24 and Aug. 7. The last application was omitted from Rows 4 and 11. All liquids were applied with a knapsack sprayer and care was taken that each row received practically the same quantity. In all cases where Paris green was used (except on Rows 1 and 8), it was used at the rate of one ounce of Paris green to four gallons of liquid. The first application was made when the plants were about six inches high.

**Prevalence of insects and disease.**—No trace of late blight appeared and only a small amount of early blight. Flea beetles

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6 Fungioiroid may be purchased separately or mixed with Paris green, half and half, in pound cans ready for use. We used the latter form.

7 It was planned to use "Lion Brand" Bordeaux mixture for all five applications but the can of Bordeaux designed for use in the first application was stolen. The contents in one of the two cans subsequently used was so thick that it could not be gotten out of the can through the three-fourths inch hole provided for that purpose. It was necessary to cut out the top of the can. The other can was better in this respect, but still it was difficult to empty out the contents through the hole.
were moderately abundant and Colorado potato-beetles very abundant. For a few days after the first treatment, June 11, the potato-beetles were scarce, but by the time of the second treat-

**COMPARATIVE EFFECT OF DIFFERENT FUNGICIDES AND INSECTICIDES UPON YIELD OF POTATOES.**

<table>
<thead>
<tr>
<th>Kind of treatment received.</th>
<th>Product of the two rows.</th>
<th>Computed yield per acre.</th>
<th>Increase in yield of merchantable tubers per acre using the two rows treated with Paris green in lime-water as a basis of comparison.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fungiorid and Paris green, 5 times.</td>
<td>7.25</td>
<td>3.00</td>
<td>62.50</td>
</tr>
<tr>
<td>Paris green in lime-water, 5 times.</td>
<td>8.00</td>
<td>2.50</td>
<td>68.75</td>
</tr>
<tr>
<td>Paris green in lime-water, once; “Lion Brand” Bordeaux + Paris green, 4 times.</td>
<td>8.38</td>
<td>1.75</td>
<td>72.25</td>
</tr>
<tr>
<td>1-to-7 Bordeaux + Paris green, 4 times.</td>
<td>10.63</td>
<td>1.50</td>
<td>91.50</td>
</tr>
<tr>
<td>1-to-7 Bordeaux + Paris green, 5 times.</td>
<td>11.00</td>
<td>1.25</td>
<td>94.75</td>
</tr>
<tr>
<td>1-to-7 Bordeaux, 5 times.</td>
<td>8.75</td>
<td>1.50</td>
<td>75.25</td>
</tr>
<tr>
<td>1-to-11 Bordeaux + Paris green, 5 times.</td>
<td>11.25</td>
<td>1.00</td>
<td>97.00</td>
</tr>
</tbody>
</table>

ment, June 26, they were again abundant. The second treatment disposed of them again but they became numerous by the time of the third treatment, July 24. The third treatment, however, finished them for the season. They gave no trouble after July 24. In this experiment the fight was chiefly against the Colorado potato-beetles, and it was a hard fight. Throughout the whole season it was noticed that they were the most numerous on rows 1 and 8, treated with Fungiorid and Paris green. Rows 2 and 9 seemed to suffer to about the same extent as rows 3 and 10. The rows to which ordinary Bordeaux mixture had been applied did not suffer nearly so much as the other rows, and among the
Bordeaux rows it was noticeable that the beetles had a decided preference for those which had received no Paris green.

All of the plants dried up somewhat sooner than they should have done. They did not, however, die from any disease, but from lack of proper cultivation.

**Results.**—The results of the experiment are tabulated on the preceding page.

The seven kinds of treatment arranged in the order of their value would, therefore, stand as follows:

1. Bordeaux mixture (1-to-11 formula) and Paris green, 5 times.
2. Bordeaux mixture (1-to-7 formula) and Paris green, 5 times.
3. Bordeaux mixture (1-to-7 formula) and Paris green, 4 times.
4. Bordeaux mixture (1-to-7 formula) alone, 5 times.
5. Paris green in lime water, once; "Lion Brand" Bordeaux mixture and Paris green, 4 times.
6. Paris green in lime water, 5 times.
7. Fungicroid and Paris green dry, 5 times.

**Comments on the results**—We can see no reason why 1-to-11 Bordeaux should give better results than 1-to-7 Bordeaux. It was expected that the position of these two treatments would be reversed. It should be borne in mind, however, that the fight was chiefly against insects and, consequently, the value of the Bordeaux mixture lay, for the most part, in its adhesive property which caused it to hold the Paris green on the leaves. The 1-to-11 Bordeaux adheres just as well, but no better, than 1-to-7 Bordeaux. The difference (2.25 bu. per acre) is so slight as to make them practically equal. Had late blight been prevalent the results might have been different. In a season when potatoes blighted badly, Prof. L. R. Jones of the Vermont Station found strong Bordeaux decidedly preferable to weak Bordeaux, but he did not use the same formulae used in this experiment.

It was found wholly impracticable to get along with three applications of Bordeaux mixture. If any one of the first three treatments had been postponed the plants would certainly have been seriously injured by Colorado potato-beetles. And it would

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not have been prudent to omit the fourth treatment which was made July 24, because the plants would then have been unprotected against late blight which was liable to appear any time after July 15.

With Paris green, 1-to-7 Bordeaux mixture produced 19½ bushels per acre more than the same mixture without Paris green. This shows that Bordeaux mixture falls far short of furnishing complete protection against insects. Paris green must be used with it. It is to be noted, however, that Bordeaux mixture alone gave better results than Paris green in lime water, Fungiroid and Paris green applied dry, or the "Lion Brand" Bordeaux mixture and Paris green; and this, too, when insects were the chief enemies. Bordeaux mixture certainly has considerable value as a repellent of insects.

The "Lion Brand" Bordeaux mixture with Paris green was a failure, giving but 3½ bushels per acre more than Paris green in water. The experiment does not prove that it may not have some value as a fungicide, because very little fungus was encountered in the experiment; but the experiment does prove that as a spraying mixture for potatoes it is decidedly inferior to ordinary Bordeaux mixture. It lacks the adhesive property of Bordeaux mixture.

Fungiroid with Paris green made an even worse showing. The rows treated with Fungiroid and Paris green yielded 6.25 bu. per acre less than the rows treated with Paris green in lime water. There being but little fungus, this difference represents the difference between applying Paris green dry and applying it in lime water. The Fungiroid and Paris green were applied according to directions on the can; namely, at the rate of two pounds per acre, applied on dry foliage with a Leggett powder-gun and when there was but little wind. Although this experiment furnishes no information as to the fungicidal value of Fungiroid we do not hesitate to state that in our opinion the value of Fungiroid is so small as compared with liquid Bordeaux mixture that it has no claim to consideration from potato growers. Our opinion is based: (1) On the fact that Fungiroid lacks the adhesive property of Bordeaux mixture; (2) on the results of experiments at other experiment stations in which the merits of Fungiroid and Bordeaux mixture have been compared; (3) on the opinions of
eminent authorities on plant diseases. Prof. L. R. Jones, botanist of the Vermont Experiment Station experimented with Fungiroid and other forms of dry Bordeaux mixture on potatoes for two seasons. From the results of these experiments he draws the following conclusion: "When these powders were applied dry even in the most liberal amounts they gave so little protection that their substitution for the ordinary or wet mixture is not to be recommended under any circumstances." In an experiment made by Mr. H. P. Gould at the Maine Experiment Station, Fungiroid applied to potatoes increased the yield 10 per cent. while wet Bordeaux mixture increased the yield 31½ per cent. under parallel conditions. Prof. Galloway, Chief of the Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture, considers powder fungicides as a class much inferior to liquid fungicides.

The small yield on all parts of the experiment field was due to poor cultivation. The experiment furnishes a striking example of the fact that spraying cannot be made to take the place of cultivation.

ONE HUNDRED GALLONS OF BORDEAUX MIXTURE PER ACRE VS. FIFTY GALLONS PER ACRE.

The following experiment was conducted on the farm of Mr. H. L. Hallock, near Jamesport, N. Y.

Seven rows 636 feet in length were planted with of potatoes the variety White Elephant. Considerable care was taken to apply the fertilizer uniformly over the 7 rows and to cut the seed potatoes in such a way as to leave two eyes to each piece. They were planted with a potato-planter. This was on land which had grown corn the previous season.

During the season they were sprayed 5 times with Bordeaux mixture, Paris green being added in the first 2 sprays. The dates of spraying were June 9, June 22, July 8, July 22 and Aug. 6. The Bordeaux mixture was applied with a Hudson Special Bordeaux Sprayer, a cut of which may be seen in Figure 1. This sprayer is arranged to spray four rows at a time with two

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9 loc. cit., p. 98.
nozzles to each row, so that in going across the field and back again eight rows are sprayed. But instead of spraying eight rows we sprayed only seven and were thus enabled to double spray the center row; in other words, the center row received at each spraying exactly twice as much Bordeaux mixture as each of the other six rows. Since the sprayer applies Bordeaux mixture at the rate of about 50 gallons per acre, the six single sprayed rows received Bordeaux mixture at the rate of 50 gallons per acre and the double sprayed row or center row at the rate of 100 gallons per acre.

At digging time the tubers on the center row were weighed by themselves. The tubers on the other six rows were also weighed. The double sprayed row yielded 430½ lbs. merchantable tubers, 35 lbs. culls.
The six single-sprayed rows averaged 390½ lbs. merchantable tubers, 52½ lbs. culls per row.
Difference in yield of merchantable tubers, 40 lbs. per row or 15 bu. 13 lbs. per acre.

The experiment was repeated on seven other rows of potatoes 536 feet long, planted on clover sod. The treatment was the same and the result was as follows:
The double-sprayed row yielded 463¾ lbs. merchantable tubers, 22 lbs. culls.
The six single-sprayed rows averaged 403½ lbs. merchantable tubers, 21½ lbs. culls per row.
Difference in yield of merchantable tubers, 59½ lbs. per row or 27 bu. per acre.

To recapitulate, potatoes sprayed 5 times with Bordeaux mixture at the rate of 100 gallons per acre outyielded potatoes sprayed at the rate of 50 gallons per acre. The amount of the difference was in one case 15 bu. 13 lbs. of merchantable tubers per acre, and in another case, 27 bu. of merchantable tubers per acre.

As in the experiments at East Williston, the fight here was chiefly against flea-beetles and Colorado potato-beetles. There was very little disease of any kind to contend with.

The result of this experiment confirms us in a previously formed opinion based upon general observation, namely, that heavy applications of Bordeaux mixture give much better results than light applications, and that it will pay to use at least three nozzles per row in the last two sprayings.
A TEST OF THE HUDSON SPECIAL BORDEAUX SPRAYER.

Quite recently Long Island potato growers have begun to take considerable interest in the spraying of potatoes, and one of the greatest obstacles to progress in the practice of spraying is the difficulty of obtaining suitable machinery for applying the Bordeaux mixture. For gardens and small fields of from one to two acres the knapsack sprayer answers very well; but for the large fields of those farmers who make potatoes their chief farm crop, the knapsack is too tedious. In our opinion the most economical method of spraying these large fields is by means of a home made outfit similar to the one shown in Plate I. There are, however, many farmers who object to the labor required to operate such an outfit. They desire a sprayer so arranged that all of the work is done by horse power. Sprayers of this description are necessarily somewhat complex and consequently expensive. Several different kinds have been placed upon the market but they have been so defective in various ways that farmers have become suspicious of this class of sprayers. The perfect power sprayer for potatoes has not yet appeared.

In the spring of 1896, the Riverhead Agricultural Works, Riverhead, N. Y., put out a new Hudson Special Bordeaux Sprayer. This machine having certain new, and, apparently desirable features, and being manufactured and sold by a firm located in the potato growing section of Long Island, it seemed necessary for us to test it so that we might be able to answer correctly the inquiries which are certain to arise concerning it.

We used it throughout the season of 1896 for spraying about 7 acres of potatoes near Jamesport, Long Island, and found it quite satisfactory. One of the strong points of the sprayer is the manner in which the nozzles are arranged. There are two nozzles to each row and they can be readily adjusted to suit the size of the plants. We are thoroughly convinced that one nozzle per row is entirely insufficient, except perhaps, for the first spraying.

We experienced very little difficulty from clogging of the nozzles. The Bordeaux mixture is drawn from the bottom of the
barrel and this is generally considered an objectionable feature, since there is more liability of the nozzles clogging than there is when the escape tube leaves the barrel from the top. But in the Hudson sprayer the agitation of the liquid is so thorough that this difficulty is overcome, provided a reasonable amount of care
is used in straining the Bordeaux mixture and in rinsing out the barrel. The ease with which the barrel can be filled is another good feature of the machine.

This sprayer should give excellent satisfaction, if in operating it the following rules are heeded:

(1) *The Bordeaux mixture must be thoroughly strained.* The strainer furnished with the sprayer is entirely sufficient. Everything that goes into the barrel should be passed through this strainer. There need be no difficulty in getting Bordeaux mixture through the strainer if the Bordeaux is properly made. First of all, see that the barrel in which the Bordeaux is to be mixed is free from sticks and dirt—rinse it well. Always strain the lime-water and if there is dirt in the water, strain it also. With proper management this straining process need not consume much time and in the end there will be a great saving of time. Avoid a great excess of lime in the Bordeaux.

(2) *At the close of each day's work pass a small quantity of clean water through the nozzles and rinse the barrel.* This should always be done but is most important when Paris green is used with the Bordeaux mixture.

**DIRECTIONS FOR SPRAYING POTATOES ON LONG ISLAND.**

Spray every season. Begin when the plants are from six to eights inches high and spray once every two weeks as long as the plants continue green. If heavy rains occur it may be necessary to spray somewhat oftener, particularly in seasons when late blight is prevalent. Use Bordeaux mixture of the 1-to-8 formula; that is, use one pound of copper sulphate for every eight gallons of Bordeaux mixture. When Colorado potato-beetles or flea-beetles are abundant add Paris green to the Bordeaux mixture at the rate of three-fourths of a pound of Paris green to 50 gallons of Bordeaux mixture. Spray thoroughly. If a sprayer with stationary nozzles is used there should be two nozzles per row in the first three sprayings and three nozzles per row in all subsequent sprayings. It is, however, sometimes difficult to arrange the nozzles so that three per row can be used with advantage. In such cases it may be advisable to use, instead, two nozzles per row
and go over the plants twice in opposite directions. By all means, spray thoroughly in the latter part of the season.

This treatment can be depended upon to prevent early blight and late blight or rot, keep off Colorado potato-beetles and considerably reduce the amount of damage done by flea-beetles.