SPRAYING FOR ASPARAGUS RUST.

I. TESTS WITH RESIN-BORDEAUX MIXTURE.
II. THE DOWNS' POWER ASPARAGUS SPRAYER.

F. A. SIRRINE.
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BULLETIN No. 188.

SPRAYING FOR ASPARAGUS RUST.

F. A. SIRRINE.

SUMMARY.

All three stages of asparagus rust appear in this State. More than one stage can occur in the same rift or sorus.

Cutting and burning early in the fall to destroy the rust is injurious to the asparagus plants and is not recommended.

Thus far, in this State, no variety of asparagus has entirely withstood the attacks of the rust.

In 1898-1899 a gain of 69.5 per ct. in yield, equivalent to a financial gain of 94 per ct., was obtained by spraying; and in 1899-1900, under unfavorable conditions, a gain of 47.8 per ct. in yield or 44.5 per ct. in value. In no case did injury to the asparagus result from the use of resin-Bordeaux mixture.

A specially-constructed power sprayer was used to advantage in our work. This sprayer met all the requirements of an ideal machine, did the work more thoroughly and rapidly than could be done by hand, and also saved materials. It is not patented. Probably such a machine cannot be built for much less than $200.00. It is recommended that those who grow less than 5 acres undertake the building of such machines only in cooperation with others.
I. TESTS WITH RESIN-BORDEAUX MIXTURE.

INTRODUCTION.

Asparagus rust, *Puccinia asparagi* DC., has been more or less prevalent in this State during the past five years. Each year it has reduced the vitality of the plants, until the growing of asparagus in the market garden section around New York City has been practically abandoned. In sections like the east end of Long Island and Oneida and Madison counties, where the canning factories take the larger portion of the crop, the growers are tenaciously retaining their beds although harvesting a lighter crop each year. The records of the Hudson Canning Co., Mattituck, N. Y., show that the average yield per acre for seasons prior to the outbreak of the asparagus rust varied between 1,500 and 2,500 bunches, while during 1899 and 1900 the average yield varied from 800 to 750 bunches per acre.

Some growers, however, are increasing their acreage, hoping that the rust will not be as bad in the future; that some variety will prove rust-proof; or that some other means of controlling the disease will be found. That the first two of these methods of relief are possible has been the opinion of several eminent pathologists; but thus far no such conditions have been reached. The rust, instead of abating, has been rapidly increasing in destructiveness; and no strictly rust-proof varieties have, as yet, been found. It is true that in some sections the Palmetto variety has been reported as being partially rust proof; but it has not proven itself so under the conditions found in this State. In fact, it was one of the first varieties to be injured by the "cluster cup" stage in 1900. Even the Argenteuil, which is being put forward at present as rust proof, succumbed to the attacks of the rust during the past season. Whether it was as badly injured as some other varieties cannot be said, as it was not observed growing under field conditions.

In addition to resistant varieties, the following have been advocated as means of controlling the rust: Methods of cultivation and fertilization, burning, and even planting on heavy soils.
Spraying has also been suggested; but for reasons given further on, most writers on asparagus rust have held out but little hope along this line.

The persistence of asparagus rust, with the evident ruining of the canning industry, if not of the culture of asparagus as a money crop, by its attacks, not only in this State but also in other sections of this country, convinced us that it was necessary to determine definitely whether there could not be found some methods or combination of methods by which this trouble can be controlled. It was also desirable to determine whether such methods could be put to practical use by the growers of asparagus. Some practical results have already been obtained and, as delay means additional loss each year to growers, the following preliminary report on the work is given.

HISTORY AND DISTRIBUTION OF THE RUST.

Asparagus rust has been known in Europe for nearly one hundred years, although English writers on asparagus culture do not mention its occurrence in that country until about 1876. Barnes and Robinson state that its attacks on the part above ground have an unfavorable effect on the roots, checking their development. This causes a material reduction of the yield the succeeding spring owing to the premature ripening of many of the plants. Although the above writers were not positive regarding the nature of the disease, they were sure of its dangerous character and recommended that growers be careful to prevent its spread or its importation into districts that were free from it.

Although asparagus growers on Long Island and in the vicinity of Cape Cod believe they saw the effects of the asparagus rust in their fields as early as 1895, it was practically unknown in this country until 1896. In that year Dr. Halsted announced the occurrence of an outbreak of the asparagus rust in New Jersey. This announcement led to the discovery that the disease was already established in the asparagus fields of Delaware, Long Island and New England. Since 1896 it has been very destruc-

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1 Asparagus Culture, p. 22.
tive in these localities and has spread south into the Carolinas and west to Kansas, Iowa and Wisconsin.

How and when the rust was introduced into this country is not known. It is possible that it was imported from Europe on plants or with the seed a number of years prior to its discovery and, like the gipsy moth, required several years to become well enough established to be noticed. Although it is not known for how long a period the spores of the rust can withstand the drying effect of the wind, there is little doubt that the latter is one of the principal agents in distributing the rust over the country. It has certainly spread over a larger extent of territory during the past few years than would have been possible through distribution of the spores on asparagus plants and seeds.

DESCRIPTION.

Asparagus rust has been frequently described during the past few years; and its wide distribution makes it a well known disease; yet it is deemed best to repeat briefly some of its characteristics as a basis for clear understanding of the experimental work herein reported.

It is a parasitic plant, or fungus, growing within the asparagus and absorbing the juices which should go to build up the tissues of the latter. The portion of the rust plant which we see and which gives it its name, is simply the spores, or seeds, of the fungus. These are formed beneath the epidermis, or bark, of the asparagus plant, causing this epidermis to lift and form pustules which, in two stages, produce slits or rifts. All are called sori. (See Plates I and II, Figs. 1.)

The rust has three rather distinct stages or forms of growth. All three can occur on the same plant and frequently more than one form occurs at the same time.

Æcidial stage.—The first form, known as the Æcidial or "cluster-cup" stage (see Plate I, Fig. 1), and sometimes called the "spring form" of the rust, is not usually distinguished from the second stage by growers of asparagus. It makes its appearance upon seedling beds and old neglected beds, as well as upon volunteer asparagus, on Long Island about the first of June. In the above

3 P. H. Rolfs has reported finding the rust spores adhering to the asparagus seed. S. C. Agr. Exp. Sta. Rept. 1899, p. 17.
section where ridging is practiced this stage is rarely seen on the cutting beds but as seedling beds and neglected beds are always plentiful there is an abundance of the spring form.

In this first stage the spores are formed in cup-shaped pustules. These pustules or cups are grouped in clusters; hence the name of "cluster-cup." Examination with a lens shows that the cups are often of two kinds, associated together. Those of one form are called spermogonia, while the others, in which the spores are borne in bead-like chains, are called aestidia (see Plate I, Fig. 2, a and b). These cups are frequently arranged in oval and spindle-shaped groups upon the stem as shown in Fig. 1, Plate I, but nearly the same shapes are assumed by the other stages of the rust, hence this cannot be given as a definite characteristic. The cups never show as rifts or slits as do the later stages. At first they are greenish-yellow in color, but as they mature they change to an orange-yellow. Sometimes the cluster of cups shows only watery pustules; these are the spermogonia. In June, 1900, this stage was more prevalent on Palmetto seedling beds than on any other variety.

Uredo stage.—The second form, commonly called the "summer" stage and "red-rust" stage, is the one usually first noticed by growers. It is in this stage of growth that the rust increases and spreads most rapidly, and apparently does the greatest amount of damage. In this form the epidermis, or skin, of the asparagus appears to be covered with slits and rifts from which red granules or spores are exuding. These rifts are often grouped in oval and elliptical clusters on the stems, as in the first stage; but, instead of being cup-shaped pustules, they always occur as slits in the bark. It is this stage that gives the asparagus fields their peculiar brown color in such a short interval of time, and coats machinery and workmen with a red dust. The spores are one-celled, smooth, rather thin-walled and of a reddish-brown color (see Fig. 3, u, Plate II).

Teleutospore stage.—The last stage is frequently called the "black" rust and "winter" stage. To the unaided eye there is no difference except in color, between this and the second stage. Close examination will show that the rifts are filled with dark brown spores which do not rub off and scatter as easily as the red
rust spores. These winter spores are two-celled, are larger, and have thicker cell walls than those of the red rust (see Fig. 3, t, Plate II). They are always formed whenever the vitality of the asparagus plant is reduced or its growth checked, no matter what the season of the year, whether early June or late October. According to Dr. Halsted¹ all three stages can occur at once on the same plant. It is supposed that these spores do not germinate until the following spring, at which time, if they succeed in getting a foothold on a young asparagus plant, they soon produce the first stage.

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EXPLANATION OF PLATES FOR ASPARAGUS RUST.

PLATE I. Fig. 1—Ecidial or "cluster-cup" stage of Puccinia asparagi showing sorii made up of clusters of cup-shaped pustules. Magnified 3 diameters.

Fig. 2—Cross-section of one of the sorii of Fig. 1, showing (a) spermospores, (b-b)aecidial cups; one broken, with spores escaping, also one not broken open. Magnified 25 diameters.

PLATE II. Fig. 1—Uredo, or "red-rust," stage of asparagus rust showing form of sorii, or rills in the bark of the asparagus stem. Magnified 2 diameters.

Fig. 2—Cross section of one of the sorii shown in Fig. 1, (u) uredospores, (t) teleutospores. Magnified 75 diameters.

Fig. 3—Uredospores and teleutospores. Magnified 75 diameters.

PLATE III. General view of asparagus field sprayed fall of 1898, showing sprayed belt on the right. Taken Sept. 27, 1898.

PLATE IV. Nearer view of field shown in Plate III.

PLATE V. View of field sprayed 1899 and 1900, showing alternate rows sprayed. Taken Sept. 15, 1900.

PLATE VI. Field shown in Plate V, looking across rows.

It is not known that it is absolutely necessary for the rust to pass through the three different forms named each year, or through any two of them. The last two forms may occur in the same rift or sorus, being produced by the same vegetative portion, or mycelial thread, of the fungus (see Fig. 2, Plate II); possibly all the forms may be produced in the same way. All three forms certainly occur in this State: the first is found principally during the month of June; the second occurs during the latter part of June, and throughout the months of July, August, September

Plate I.—Gross and Microscopic Characteristics of Cluster-Cup Stage of Asparagus Rust.
Plate IV.—Unsprayed and Sprayed Asparagus.
(Nearer view of field in Plate III.)
PLATE VI—ALTERNATE ROWS OF ASPARAGUS SPRAYED

(Same field as in Plate V. Looking across rows)
and October; the third follows the second as soon as the asparagus commences to lose its vitality or begins to mature.

METHODS OF CONTROLLING.

BURNING.

One of the first methods suggested by writers for checking the spread of asparagus rust, was burning the affected brush. In fact this has been the principal method recommended by European writers such as Zimmerman, Frank and Abbey. At first Dr. Halsted recommended the same treatment. Drs. Sturgis and Stone followed Dr. Halsted's advice as did also Messrs. Jones and Orton. In a later published work Dr. Halsted says: "At best, with these precautions, many of the spores will get scattered upon the soil." Mr. Kinney, of Rhode Island, questioned the advisability of burning the brush in late summer; and later Messrs. Stone and Smith took a similar view of burning, stating that they had only recommended burning the infected plants late in the fall when they were thoroughly dead and dried out; and that they had never seen the slightest benefit from burning the infected tops, while cases had been brought to their attention in which actual injury had resulted from cutting the tops and burning them in August. Following all the above suggestions Dr. Pammel in a recent bulletin recommends burning as undoubtedly the best method of preventing the rust.

There is no doubt that in some sections the above measure has been abused. A few agricultural papers have recommended cutting and burning the beds as soon as the rust is observed. As a result some growers have followed the latter method with more

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5 Atlas Pflanzen Krankheiten.
13 Rural New Yorker, 56: 658, Oct. 9, 1897.
harm than benefit to their crops. In 1899 this was tested on two acres of Columbian White asparagus at Mattituck, New York. On August 14, every spear of the asparagus was cut and removed from the field, by the owner. Two weeks later a fairly good stand of half-grown asparagus stalks covered the field. On September 7, this new growth was badly rusted, and by the first of October it was as nearly dead as was the first growth previous to cutting. As a result, the bed was so weakened that it had to be abandoned in 1900. The author believes that American writers never intended to recommend cutting early in the fall, although in an article in *Garden and Forest* Dr Halsted
\(^{16}\) says, "The only safe thing to do when a serious enemy like this is in an asparagus field is to burn the plants even to the last scrap that can be gathered up. Let this be done at once, for any delay means the breaking up of the brittle, rusty plants, and a generous sowing of the spores upon the ground." Unfortunately Long Island growers are not the only ones who have tested cutting and burning too early in the fall.

In asparagus growing sections like Long Island where a large amount of asparagus grows wild in hedge rows and neglected fields, where also worn-out fields are allowed to run wild, it is doubtful if cutting and burning even late in the fall will ever be of much benefit. Even with a law compelling all growers to cut and burn their beds in October, it still remains an open question whether the spores which fall to the ground will not thoroughly seed the field for another season.

In addition to burning Dr. Halsted
\(^{17}\) has suggested plowing and the application of lime as a means of disposing of the scattered spores which lie on the surface of the field. This method may be worth a trial where level culture is practiced, but would be of little value where ridging is followed.

**RESISTANT VARIETIES.**

In 1896 Dr. Halsted
\(^{18}\) noticed that the Palmetto variety was apparently not injured as much by the rust as some other varie-

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\(^{16}\) *Garden and Forest*, 9: 395, 1896.


ties. A year later Mr. Kinney reported the same condition in Rhode Island. During the past three years Dr. Halsted has reported the Palmetto as showing less rust than other varieties in New Jersey. As already stated, in 1900 recently-set Palmetto plants were injured more by the spring stage of the rust than were the Conover's Colossal plants of the same age in the same field. Similar conditions occurred on the fields of the Oneida Community Limited, in Madison County, New York. In one field containing several varieties, the Palmetto showed no advantage over the others. The fields on Long Island have been watched every year since 1896 with the result that only slight, if any, differences in favor of the Palmetto were to be noticed, except that in some cases it did not succumb as early. Of course there is a bare possibility that the Long Island growers have a weak strain of the Palmetto variety. More frequently greater differences would be seen in the same variety, apparently due to such factors as age of the bed, situation with regard to other fields and proximity of windbreaks. At present several other varieties are being advertised as "rust proof." Undoubtedly seedling varieties will be found which will succumb to the attacks of the rust more slowly than others; but as the beds get older or a little mismanagement exhausts them they will finally get started downward and then go under. Hence at present we would recommend that no one put too much faith in "rust proof" varieties and expect them to resist the continued attacks of the rust without some effort on the part of the grower to check the spread of the disease.

**SOIL CONDITIONS.**

Mr. Kinney, Botanist of the R. I. Station, says, "So far as observed neither the character of the land nor the kind of fertilizer used, nor the method of cultivation practiced has had any noticeable influence upon the development of the asparagus rust."

Two years later Messrs. Stone and Smith, of Massachusetts, say, "The injurious effects of the rust have been confined to dry

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10 Rural New Yorker, 56: 658, Oct. 9, 1897.

sandy soils possessing little capacity for holding water. Where the soil is heavier, possessing more water-retaining qualities, the rust has caused no perceptible harm.” In a still later report\(^2\) the same writers endeavor to show “the susceptibility of plants growing in localities possessing soil with little water-retaining properties.” Their conclusions are based upon an extensive study of the localities affected, also upon mechanical analyses of the surface soils from ten different sections of the State where asparagus is grown. They also assert that the summer (uredo) stage is limited in its distribution in Massachusetts and is found only on those soils which are sandy and possess little water-retaining properties, whether they are located near the coast or inland.

In conclusion they recommend the selection of soils, for new beds, which possess considerable water-retaining capacity, even if such soil is not adapted quite so well for asparagus during ordinary seasons. For old beds they recommend increasing the soil moisture by irrigation, by increasing the organic matter, and by mulching.

Unfortunately nearly all the asparagus sections of Long Island are situated in what Messrs. Stone and Smith have classed as coast lands. A few fields are situated in the drift soils of the terminal moraine, but for the most part they are situated on drift and wash sands. The best of the soils are what are called sandy loams. Differences due to what was considered the vitality of individual plants, also to protection by timber belts, corn fields and other windbreaks, have been observed. In no case in this section have differences been noted which could be traced to soil conditions. In many cases where the fields are situated on wash sands the water-table is so near the surface that the roots of the plants could easily reach the water; while the moraine soils often have a depth of fifty to one hundred feet to the water-table.

Thus far the only differences to be seen in the Long Island fields were apparently due more to the fact that the rust got started earliest on the sandy lands and then drifted to the fields on the moraine soils. In all cases both the summer and winter stages were always present. Of course the fact of the rust starting on the low sandy lands may result from the influence of the

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factors set forth by Messrs. Stone and Smith. As will be shown further along we think a still different factor enters into the above conditions.

About the middle of September the writer visited the asparagus fields of the Oneida Community Limited and the surrounding country in Madison and Oneida counties. He was first taken to a six-acre field situated in the bend of a stream, no point of which was over eight feet above the lowest stage of the creek. The surface of this field, was called a clay loam, and was an alluvial deposit formed by a bend in the stream. The original banks of the stream consisted of a shaly clay and were some thirty feet higher than the asparagus field. The variety of asparagus on this field was Moore’s Hybrid. The only portion of the field that was not entirely killed was on the tangent side of the bend next the original bank of the stream. This bank was covered with a vineyard and furnished a partial windbreak to the southwest of the asparagus field.

The next field of thirteen acres was a new bed of Barr’s Mammoth asparagus set the spring of 1900. It was situated a half mile further down the stream, to the northeast of the first field but on the high ground, about fifty feet above the stream. The soil was a clay loam with a small amount of gravel intermixed. At a distance this field appeared to be entirely free from the rust; closer inspection showed that it was slightly infected with both the summer and winter stages of the disease. The same conditions on newly set fields had been noted on Long Island, namely, that the rust did not attack them until late in September, but in all such cases the fields were isolated and surrounded by woodland.

A third field of ten acres was next inspected. A small stream runs through the latter and joins the larger stream. Part of the field had once been a swamp which had been drained and loamed before setting to asparagus. In fact one portion of this field showed a clay loam, another stiff clay, another clay with shale and cobble stones intermixed and still another was black muck loamed on the surface. No portion of the field is over eight feet above the water-table and over most of the field water could be reached within five feet. On this field there were growing nine rows of Palmetto and thirteen rows of Moore’s Hybrid, the remaining rows being unknown varieties.
Only slight differences in the amount of rust on any of the above varieties were noticeable, the best portions showing the yellow-brown color of a badly rusted field. Both stages of the rust were found here.

A member of the Company, Mr. Hinds, kindly drove me to another field of fifteen acres located on higher ground. This field, consisting of Moore's Hybrid and Conover's Colossal, is situated on a side hill, the top being about eighty feet and the base fifty feet above the creek. The rows of asparagus are long and straight, not following the contour of the hill. The soil is a sandy loam with some clay and enough humus to make a black sandy loam. Apparently the soil is the same in all parts of the field. About one-third of the field consists of a new bed which had been set two years but had not come into cutting. This new portion is on the lowest part of the field, near the base of the hill. The remaining two-thirds of the field are older beds which had been cut for four or five years and at the same time had received liberal applications of stable manure, 15 to 20 loads per acre each year. This older portion covers the crest and upper half of the side of the knoll. Aside from manuring, the whole field had received the same cultivation the past year.

The asparagus on the top of this hill was so free from the rust that we had to search some time before finding an infested stalk. Following down the rows we soon came to a belt of yellowish-green plants; here the rust was plentiful. A little further down, the plants were all brown, with little foliage left, and still further down the hill on the new bed the plants were naked and gray-black with Darluca and the winter stage of the rust. As in all the other fields both stages of the rust were found. The peculiar belts of brown plants with little foliage, yellowish-green plants with some foliage, and last the green plants showing very little rust, all following the contour of the hill and not limited to the new bed, were very marked. If these belts had been limited to the new bed and to only a small portion of the old bed adjoining, all the conditions might be accounted for by assuming that the rust had started early in June on the new bed and had gradually spread to the older bed after the cutting season was over. If the new bed had been so situated that prevailing
winds could carry the rust to the older portion of the field, the con-
ditions found could have been considered the result of the rust start-
ing early on the new bed and spreading in curves by aid of the
winds. As a matter of fact the rows run east and west, and the
contour lines of the hill extend from south to north northwest,
the slope being east-northeast. The new bed is on the east end
of the field. The slightly rusted portion of the field was on the crest
of the knoll. Undoubtedly the rust had attacked the new bed
early in the season, but this would not account for the rust belts
following the contour of the hill and infecting the old bed on the
north side. It was said that the rust affected the field in the same
manner the previous year.

As far as known there are no tests showing that it is absolutely
essential for the spores of the summer stage of the rust to have a
nidus of water in which to germinate under natural conditions.
It is an assumed fact among pathologists that the spores of all
kinds of fungi, including the rusts, require drops of water in which
to germinate. Water certainly is required to germinate them
under artificial conditions. If this is a correct assumption, then
the fact that an abundance of moisture had been furnished for the
germination of the rust spores in the form of dewdrops, might
account for some of the conditions found in the above field.
Now it is often observed that low lands and those adjoining
streams get heavier dews than does the high ground; also, that
air currents affect the distribution of the dews; that is, dews are not
evaporated as rapidly on the windward side of a hill. Although
the base of this field is as high as any of the fields of the Oneida
Community Limited yet the land adjoining it on the northeast is
low and moist. All these conditions indicated that dews might
have had more to do with the fostering of the rust than had any
other condition, such as cultivation, fertilization, soil conditions
and varietal differences, which man could furnish. Taking the
conditions as they were, it appeared that dews had been the prin-
cipal fostering agent in the fields of the Oneida Community
Limited, the only exception being in the case of the new field of
Barr's Mammoth. This field, as stated, is about fifty feet above
the stream and nearly level. In addition it is open to wind cur-
rents from all directions.
The supposition that fogs and dews have more to do with the varying conditions found regarding the rusting of asparagus fields applies in all cases on Long Island. It is a common occurrence to have a week or ten days during each month of the fall on which the sun is not seen until 10:00 A. M. The low grounds always get the larger portion of these fogs.

Although Messrs. Stone and Smith do not state whether the fields examined by them were on high or low ground, they give the post office address of each locality. A study of the contour map of the State of Massachusetts shows that four of these localities are less than one hundred feet above sea level; that is, they are in sections which are reached by sea fogs, while a fifth locality is in the valley of the Connecticut River. From what has been observed regarding conditions in this State it would seem as if the factor of fogs and dews might play an important part in the conditions found in the State of Massachusetts.

SPRAYING.

From the fact that all the true rusts which attack plants are internal parasites, that is, they grow and develop within the plant and do not show themselves on the surface of the plant until mature enough to form their spores, writers on plant diseases have not considered spraying a very practical nor promising method of preventing the rust. In the special case of asparagus which has dense as well as very smooth foliage, spraying is a much more difficult task than is the spraying of many other plants. Still another difficulty which some have set forth as a disadvantage in asparagus spraying is the lack of suitable machinery to do the work on a large scale. In addition to the above factors the preliminary work done by Dr. Halsted\textsuperscript{23} showed an advantage from spraying of only about 20 per ct. and more recently Dr. Halsted\textsuperscript{24} has reported injury to asparagus from spraying. Basing their conclusions upon these results, combined with the difficulties to be overcome, several writers have questioned the advisability and economic value of spraying.

EXPERIMENTS ON LONG ISLAND, 1898-'99,

The results given by Dr. Halsted were based upon estimates of the percentages of rusty plants on sprayed plats and on unsprayed plats, a difficult method in the case of asparagus with its dense foliage. It appears that a much fairer method would be to select a cutting bed which is old enough to be in its prime, and determine whether any difference in yield by weight could be obtained as a result of spraying. Furthermore the persistence of the rust each year together with the resultant weakening of the beds and a decreasing yield as shown by the records of the canning factory, called for vigorous measures of some description. Hence in 1898 arrangements were made with Mr. Arthur L. Downs of Mattituck, N. Y., to spray a portion of one of his Columbian White asparagus fields.

As this work was started too late in 1898 to carry out that year all the details required for a complete experiment, a trial strip of three rows, one-fifth acre, was sprayed. The principal object of this test was to determine whether a resin solution could be used to advantage for making the Bordeaux mixture adhere to the foliage of the asparagus and at the same time not injure it.

NOTES.

The three rows were sprayed three times—August 5, 17, and September 1, one barrel of the resin-Bordeaux mixture being

55 At the time, we were conducting some illustrative field work on pickle spraying on Mr. Downs' place, hence we had apparatus and materials handy for spraying of asparagus. Furthermore Mr. Downs is a practical and reliable farmer, a graduate of Cornell University, and a man interested in doing good, careful work, especially in experimental lines.

56 Resin-Bordeaux mixture was prepared by first making the Bordeaux mixture in the usual way, the 1-to-8 formula being used and the amount of lime being determined by test; after which two gallons of stock solution of resin was added to every 48 gallons of the Bordeaux mixture, the whole being stirred. By testing it was found best to dilute the stock resin solution with 8 parts of water before adding it to the Bordeaux mixture, that is, in preparing a 50-gallon barrel of mixture, the copper sulphate and lime were diluted enough to make 40 gallons after which 2 gallons of stock resin solution was diluted to 10 gallons, then added to the Bordeaux mixture.

The formula for preparing a stock solution of resin has been given in Bulletin 144 of this Station, but for convenience it is repeated here. The proportions are as follows:
used in each application. On Sept. 9, a slight difference between sprayed and unsprayed rows could be seen. The unsprayed portion was stripped of its foliage and all dead by October 7; the sprayed rows held most of their foliage until killed by frost. Plates III and IV, taken Sept. 27, show only partially the apparent difference between sprayed and unsprayed portions of the field. The mixture adhered to the plants well and was not easily removed by rains. The main difficulty encountered was to get the workmen to keep the nozzles constantly under motion and at the same time reach all sides of the plants. The least hesitancy meant drenching the foliage until the liquid ran off in drops. No trace of injury to the foliage by resin-Bordeaux mixture was found. The outfit used for the spraying consisted of an "Eclipse" pump mounted in a barrel and carried in a two horse cart. Two leads of hose were attached and each workman sprayed one side of a row at a time.

RESULTS.

In 1899, records in pounds and ounces of the cuttings from the center row, one fifteenth acre, of the sprayed belt, and of an adjoining unsprayed row, were kept. The first cutting was made May 6, and the last one on July 1. In all forty-five cuttings were taken from each row, the amount of each cutting weighed separately. The asparagus was bunched and sold to the Hudson Canning Company at Mattituck, N. Y. Primes sold at 14 cents and culls at 6 cents per bunch.

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td></td>
<td>5 lbs.</td>
</tr>
<tr>
<td>Potash lye</td>
<td></td>
<td>1 lb.</td>
</tr>
<tr>
<td>Fish oil</td>
<td></td>
<td>1 pt.</td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td>5 gal.</td>
</tr>
</tbody>
</table>

In preparing large quantities of the resin solution it was found unnecessary to follow all the precautions given in Bulletin 144; also that it could be prepared more rapidly by simply placing the oil and resin in the kettle, heating them until the resin was dissolved, then remove kettle from fire and allow the mass to cool slightly after which the solution of lye is added slowly, the whole being stirred while adding the lye. After adding the lye the kettle should be again placed over the fire and the required amount of water added. The whole should be boiled until the solution will mix with cold water, forming an amber-colored solution. Care should always be taken to have the resin and oil cool enough so that when the solution of lye or the water is added, the whole mass will not boil over and catch fire.
On three dates the cuttings from each row were bunched separately. The weights of these cuttings, together with the number and value of prime and cull bunches, were as shown in the following table:

Table I—Character and value of yield of unsprayed and sprayed asparagus.

### UNSPRAYED ROW.

<table>
<thead>
<tr>
<th>Date</th>
<th>Yield in pounds</th>
<th>Bunches</th>
<th></th>
<th>Value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Primes</td>
<td>Culls</td>
<td>Total</td>
</tr>
<tr>
<td>May 24</td>
<td>9.1</td>
<td>1.0</td>
<td>1.5</td>
<td>2.5</td>
<td>$0.14</td>
</tr>
<tr>
<td>June 9</td>
<td>9.8</td>
<td>2.0</td>
<td>1.0</td>
<td>3.0</td>
<td>$0.28</td>
</tr>
<tr>
<td>June 19</td>
<td>10.8</td>
<td>2.5</td>
<td>1.0</td>
<td>3.5</td>
<td>$0.35</td>
</tr>
<tr>
<td>Total</td>
<td>29.7</td>
<td>5.5</td>
<td>3.5</td>
<td>9.0</td>
<td>$0.77</td>
</tr>
<tr>
<td>Average</td>
<td>9.9</td>
<td>1.8</td>
<td>1.2</td>
<td>3.0</td>
<td>$0.26</td>
</tr>
</tbody>
</table>

### SPRAYED ROW.

<table>
<thead>
<tr>
<th>Date</th>
<th>Yield in pounds</th>
<th>Bunches</th>
<th></th>
<th>Value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Primes</td>
<td>Culls</td>
<td>Total</td>
</tr>
<tr>
<td>May 24</td>
<td>16.5</td>
<td>4.3</td>
<td>1.0</td>
<td>5.3</td>
<td>$0.60</td>
</tr>
<tr>
<td>June 9</td>
<td>14.3</td>
<td>4.0</td>
<td>1.0</td>
<td>5.0</td>
<td>$0.56</td>
</tr>
<tr>
<td>June 19</td>
<td>17.7</td>
<td>4.7</td>
<td>1.0</td>
<td>5.7</td>
<td>$0.66</td>
</tr>
<tr>
<td>Total</td>
<td>48.5</td>
<td>13.0</td>
<td>3.0</td>
<td>16.0</td>
<td>$1.82</td>
</tr>
<tr>
<td>Average</td>
<td>16.2</td>
<td>4.3</td>
<td>1.0</td>
<td>5.3</td>
<td>$0.61</td>
</tr>
</tbody>
</table>

### AVERAGES.

<table>
<thead>
<tr>
<th></th>
<th>Yield in pounds</th>
<th>Bunches</th>
<th></th>
<th>Value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Primes</td>
<td>Culls</td>
<td>Total</td>
</tr>
<tr>
<td>Sprayed</td>
<td>16.2</td>
<td>4.3</td>
<td>1.0</td>
<td>5.3</td>
<td>$0.61</td>
</tr>
<tr>
<td>Unsprayed</td>
<td>9.9</td>
<td>1.8</td>
<td>1.2</td>
<td>3.0</td>
<td>$0.26</td>
</tr>
<tr>
<td>Differences</td>
<td>6.3</td>
<td>2.5</td>
<td>0.2</td>
<td>2.3</td>
<td>$0.35</td>
</tr>
<tr>
<td>Percentages</td>
<td>63.5</td>
<td>138.0</td>
<td>16.0</td>
<td>76.0</td>
<td>134.00</td>
</tr>
</tbody>
</table>

It will be seen from the above tables that the average weight of a bunch previous to trimming is approximately 3 lbs. (The cuttings were weighed before bunching; as a result the yield in pounds includes the weight of trimmings). As the yield in
pounds and ounces of the sprayed and unsprayed rows was kept the entire season, the total number of bunches obtained from the sprayed and unsprayed rows can be estimated. It can be shown from the first section of Table I, that 61.1 per ct. of the total average number of bunches for the three cuttings on the unsprayed row are primes, also that 38.9 per ct. of these bunches are culls; while from the second section it can be shown that 81 per ct. of the total average number of bunches for the three cuttings on the sprayed row are primes, and the remaining 19 per ct. are culls.

By first estimating the total number of bunches from the total yield of each row, then from the total number of bunches estimating the number of prime and cull bunches, and arranging these in a table together with the total yield, the difference between the sprayed and unsprayed row for the entire season will be as shown in Table II.

**Table II.—Total Yield and Value of Sprayed and Unsprayed Asparagus, 1899.**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprayed row ......</td>
<td>438.2</td>
<td>118.6</td>
<td>27.4</td>
</tr>
<tr>
<td>Unsprayed row ...</td>
<td>258.4</td>
<td>53.0</td>
<td>33.0</td>
</tr>
<tr>
<td>Differences ......</td>
<td>179.8</td>
<td>65.6</td>
<td>-5.6</td>
</tr>
<tr>
<td>Percentage of gain.</td>
<td>69.5</td>
<td>123.75</td>
<td>-17.0</td>
</tr>
</tbody>
</table>

Table II shows: First, that the total yield by weight, and by bunches, of the sprayed row was nearly three-fourths more than that of the unsprayed row; second, that the prime bunches from the sprayed row were more than double the prime bunches obtained from the unsprayed row, while the culls from the unsprayed exceed the number of culls obtained from the sprayed row. The same conditions hold in values. These results are more marked when expressed in percentages. It should be remembered that each row represents one-fifteenth of an acre;
from this it can be estimated that the total gain in value from spraying an entire acre would have amounted to \$132.75.

The results brought out in the foregoing tables show distinctly that spraying asparagus to prevent the rust was not only a decided benefit to the sprayed rows but also to the grower, the value received for the increased yield being more than double the cost of spraying.

At the time of selecting the above field the growth was too young to show any appreciable difference in the rows. The three side rows were chosen as they could be reached with long leads of hose from the side of the field and in this way avoid driving over them. Later in the fall the indications were that the three sprayed rows had been in better condition previous to spraying than any of the unsprayed portion of the field. This difference may all have resulted from the spraying. In order to eliminate the advantage which outside rows usually show, the middle row of the sprayed belt was selected for keeping record of yield. Hence the results as shown should represent approximately what can be done by spraying under favorable conditions.

The fact that the area used as a basis was small, allowing factors of error to be exaggerated, lessens the value of the results as a whole, therefore conclusions as to the value of spraying should not be based upon these alone.

EXPERIMENTS ON LONG ISLAND, 1899–1900.

As the field, a portion of which was sprayed in the fall of 1898, was not uniform in growth in all its parts, another field containing 15 rows, 408 feet long, set 6 feet apart, was selected. The conditions and treatment of this field are as follows: The field contains thirteen rows of Columbian White and two rows of Conover's Colossal, the whole having been set the spring of 1893. A new bed of Palmetto joins it on the north. The field is on the terminal moraine, the soil being a sandy loam. High grade fertilizers have been applied each year at a rate varying between 1500 and 2000 lbs. Some seasons the whole of the fertilizer was applied early in the spring after which the field was either plowed shallow or gone over with the disc harrow. Generally the last week in April two furrows are thrown to the rows after which the
"ridger" is started and run every Saturday throughout the cutting season. Before each ridging the cultivator is usually run between the rows to loosen the soil. At the close of the cutting season, usually July 1, the ridges are plowed down and if all the fertilizer was not applied in the spring the remainder is put on after "plowing down." During the summer and fall growing season the field is cultivated every week or two until the ground is covered by the growth of asparagus tops. Usually the old tops are not removed until the following spring.

The plan followed was: First, to determine the yielding capacity of each row of the entire field previous to spraying, by weighing each cutting; second, to spray the growth on each alternate row during the fall; and third, during the next season, to weigh each cutting from each row as in the previous spring.

The cutting on this field was begun May 6, 1899, a total of forty-five cuttings being made on each row. The amount taken from each at each cutting was weighed separately and a record kept of the weighings. In this way we obtained the yielding capacity of each row. It was found that the rust had reduced the vitality of the field until it was yielding very lightly. The last cutting was made July 1, after which the field was ploughed down and allowed to grow. On July 28, the spraying was commenced, every other row being sprayed. The odd numbers were sprayed, the even numbers being left as checks, as shown in the following chart.
The 1–tc–8 formula Bordeaux mixture with resin solution added was used as in the fall of 1898. In all, five applications were made, the dates being July 28, August 10 and 26, September 6 and 14.

NOTES.

The rust (summer stage) showed on the unsprayed rows August 19, and by August 24, had spread to all parts of these rows. They were killed by September 10. The sprayed rows remained green until the middle of October, but observation showed that it was only the growth made between July 1 and August 10 that survived the attacks of the rust until October 15; that is, a growth that was completed, hardened, and thoroughly sprayed before the rust struck the bed. All the new sprouts which came up in the sprayed rows after the rust appeared in the field were destroyed. There were two and possibly three of these periods of late growth, namely, about August 15 and September 15. As in tests of 1898, the asparagus foliage was not injured in the least by the resin-Bordeaux mixture. Tests in laboratory
showed that the solution of copper sulphate could be neutralized by the use of the resin solution alone, but a mixture of resin soap resulted which would have been impossible to spray. Possibly the excess of potash in the resin solution was the neutralizing agent and not the resin itself. Whichever it was, this is certain: that by first making the Bordeaux mixture with lime in the usual way, and then adding the stock resin solution at the rate of one gallon to twenty-four gallons of Bordeaux mixture, a fungicide was obtained which has not injured the asparagus foliage in the least during three seasons' trials, namely, 1898, 1899 and 1900; furthermore, the resin solution aids somewhat in making the mixture adhere to the smooth surface of the asparagus.

During 1900 the crop cut from all the rows of the test acre was weighed as in 1899. As the fifteenth row showed a slight advantage in yield (about 18 pounds) over the other rows previous to spraying, its yield is not included in the tables, although it was sprayed, hence the sprayed portion was two-fifths of an acre.

RESULTS.

The first cutting in 1900 was made May 14, and the last on July 2, the total number of cuttings being thirty-eight. This method gave us not only the yield of the sprayed rows before and after spraying, but also the yield of the adjoining unsprayed rows for two seasons.

The preliminary cuttings made in the season of 1899 brought out the fact that a factor of error was introduced in cutting which affected the weights. This occurred as follows: The method of ridging every Saturday favored the cutting of larger stems, hence, of more primes, early in the week, but also more pounds of waste when bunched. Toward the end of the week as the ridges were worked down in cutting, careless cutters would cut too short making more culls but at the same time reducing the amount of waste in pounds when bunched. Furthermore, no two persons would get the same results in cutting, nor would the cuttings of one person be the same before and after a rain. Hence in 1900 the cuttings from seven sprayed rows were bunched by themselves, as were also those from the seven unsprayed rows, and a record kept of the bunches obtained at each cutting. This gave
us not only the total yield of primes and culls in addition to total yield in pounds, from sprayed and unsprayed rows, but also the money value of the sprayed and unsprayed crops. As in 1899, the primes were sold for 14 cents and the culls for 6 cents a bunch. The following tables show only summaries of weights. The records of the weights and bunches of each cutting are too bulky to be presented in tabular form.

**Table III.—Yield of Sprayed and Unsprayed Asparagus.**

**Sprayed.**

<table>
<thead>
<tr>
<th></th>
<th>Row 1</th>
<th>Row 2</th>
<th>Row 3</th>
<th>Row 4</th>
<th>Row 5</th>
<th>Row 6</th>
<th>Row 7</th>
<th>Row 8</th>
<th>Row 9</th>
<th>Row 10</th>
<th>Row 11</th>
<th>Row 12</th>
<th>Row 13</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900</td>
<td>115.4</td>
<td>127.0</td>
<td>137.3</td>
<td>125.6</td>
<td>120.8</td>
<td>115.0</td>
<td>134.4</td>
<td>764.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gain</td>
<td>22.0</td>
<td>11.6</td>
<td>20.5</td>
<td>11.2</td>
<td>13.9</td>
<td>12.2</td>
<td>19.3</td>
<td>110.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentages</td>
<td>23.5</td>
<td>10.0</td>
<td>17.5</td>
<td>9.8</td>
<td>13.0</td>
<td>11.8</td>
<td>16.8</td>
<td>14.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Unsprayed.**

<table>
<thead>
<tr>
<th></th>
<th>Row 2</th>
<th>Row 3</th>
<th>Row 4</th>
<th>Row 5</th>
<th>Row 6</th>
<th>Row 7</th>
<th>Row 8</th>
<th>Row 9</th>
<th>Row 10</th>
<th>Row 11</th>
<th>Row 12</th>
<th>Row 13</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900</td>
<td>104.4</td>
<td>114.2</td>
<td>110.6</td>
<td>116.4</td>
<td>109.4</td>
<td>110.8</td>
<td>105.4</td>
<td>771.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss</td>
<td>26.5</td>
<td>22.1</td>
<td>31.6</td>
<td>21.4</td>
<td>34.1</td>
<td>25.0</td>
<td>18.1</td>
<td>178.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentages</td>
<td>25.5</td>
<td>19.0</td>
<td>28.5</td>
<td>18.0</td>
<td>31.0</td>
<td>22.5</td>
<td>17.0</td>
<td>23.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Gains and Losses.**

<table>
<thead>
<tr>
<th></th>
<th>Rows 1</th>
<th>Rows 2</th>
<th>Rows 3</th>
<th>Rows 4</th>
<th>Rows 5</th>
<th>Rows 6</th>
<th>Rows 7</th>
<th>Rows 8</th>
<th>Rows 9</th>
<th>Rows 10</th>
<th>Rows 11</th>
<th>Rows 12</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsprayed</td>
<td>22.0</td>
<td>11.6</td>
<td>20.5</td>
<td>11.2</td>
<td>13.9</td>
<td>12.2</td>
<td>19.3</td>
<td>110.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total gain</td>
<td>48.5</td>
<td>33.7</td>
<td>52.1</td>
<td>32.6</td>
<td>48.0</td>
<td>37.2</td>
<td>37.4</td>
<td>289.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The first section of Table III shows the yield in pounds of each sprayed row, also the total yield of all the sprayed rows before and after spraying, together with the differences of the yields.
for two years. This table shows a gain from spraying on every row, and a total gain on two-fifths acre of 110.7 lbs., an average gain of 276.7 lbs. per acre.

The second section shows the yield of each unsprayed row also total yield, in pounds, of unsprayed rows for two years, together with the differences in yield. In every case these unsprayed rows show a decreased yield the second year, a total decrease exceeding the total increase of the sprayed rows in a ratio of approximately 3 to 2.

This method of showing the increased yield from the sprayed row, and the decreased yield from the unsprayed row, does not show the whole advantage of the treatment, at least in the way generally followed. The sum of the increase and decrease as shown in the third section of Table III, comes nearer the method usually adopted.

By this method the total increase as a result of spraying two-fifths acre will be 289.5 lbs. or at the rate of 723.75 lbs. increase per acre.

The method usually followed to show the advantages or disadvantages of any method of treatment is to compare the yield of the treated with that of the untreated for one season, as shown in Table IV.

**Table IV.—Comparison of Sprayed and Adjacent Unsprayed Rows, 1900.**

<table>
<thead>
<tr>
<th></th>
<th>Pounds</th>
<th>Pounds</th>
<th>Pounds</th>
<th>Pounds</th>
<th>Pounds</th>
<th>Pounds</th>
<th>Total Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprayed rows .......</td>
<td>115.4</td>
<td>127.0</td>
<td>137.3</td>
<td>125.6</td>
<td>12.8</td>
<td>115.0</td>
<td>134.4</td>
</tr>
<tr>
<td>Unsprayed rows ......</td>
<td>77.9</td>
<td>92.1</td>
<td>79.0</td>
<td>95.1</td>
<td>75.3</td>
<td>85.8</td>
<td>87.3</td>
</tr>
<tr>
<td>Gain ...............</td>
<td>37.5</td>
<td>34.9</td>
<td>58.3</td>
<td>30.5</td>
<td>45.5</td>
<td>29.2</td>
<td>47.1</td>
</tr>
<tr>
<td>Percentages ........</td>
<td>48.0</td>
<td>37.8</td>
<td>74.0</td>
<td>32.0</td>
<td>60.5</td>
<td>34.0</td>
<td>54.0</td>
</tr>
</tbody>
</table>

This table shows that there is a gain in yield of the sprayed over the unsprayed rows in every case. The total gain on two-fifths acre is 283 lbs. or at the rate of 707.5 lbs. per acre, an increase of 47.8 per ct.
As a record of the prime and cull bunches from the treated and untreated rows was kept and the value of the bunches known, the results can be compared in values and bunches as well as in total weights. Table V shows not only the total weights from sprayed and unsprayed rows, but also, the total primes and culls from each, together with their values and their differences.

**Table V.—Total Yield and Value of Sprayed and Unsprayed Asparagus, 1900.**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primes</td>
<td>Culls</td>
<td>Total</td>
</tr>
<tr>
<td>7 sprayed rows......</td>
<td>875.4</td>
<td>192.6</td>
<td>83.4</td>
</tr>
<tr>
<td>7 unsprayed rows...</td>
<td>592.4</td>
<td>121.9</td>
<td>84.1</td>
</tr>
<tr>
<td>Differences ..........</td>
<td>283.0</td>
<td>70.7</td>
<td>-.7</td>
</tr>
<tr>
<td>Percentages of gain</td>
<td>47.8</td>
<td>58.0</td>
<td>-.8</td>
</tr>
</tbody>
</table>

In general this table shows the same conditions throughout as Table II which shows results for 1899, though the differences are not as marked. When the results are compared on the same basis, namely, as percentages, it will be seen from Table II that the percentage of yield is less than the percentage of value, while in Table V, these conditions are reversed. Evidently this variation results from the varying yields of primes and culls combined with the difference in price received for them. Hence the introduction of the bunches as a means of obtaining more accurate results, while furnishing a method of determining and comparing the values, at the same time introduces another factor of variation.

Taking the results of Table V, as they are, the increased money value received from spraying two-fifths acre was barely enough to cover the cost of spraying the same. It should be remembered that the yields for 1899, previous to spraying, showed that the yielding capacity of this field as a whole was very small. The age of the field was such that it ought to have been in its prime, but previous attacks of the rust had injured it so severely that
the yield was only about one-half the average yield per acre throughout the Long Island asparagus section for the season, as the records of the Canning Company show that the average yield per acre for 1900 was about 800 bunches. In reality the yield of this field was only about one-third what a good field should yield. As an outcome, with all the precautions taken to eliminate uncertain factors, the results obtained as a whole were not as marked as were those in 1899. Some idea of the growth of asparagus on this field can be obtained from Plates V and VI taken the middle of September, 1900.

By giving the results as percentages the above conditions are somewhat eliminated and the yields expressed in this manner probably show accurately what can be done by spraying under the most unfavorable conditions. These conditions were: First, a field with a low yielding capacity; and second, a field having alternate unsprayed rows as a constant source of infection to the sprayed rows. In addition it should be observed that the even or unsprayed rows showed a slight advantage over the sprayed rows in yield previous to spraying. See Table III.

With all these disadvantages to contend with, the increased yield from spraying shows in percentages a gain in yield of 47.8 per ct., and in value 44.5 per ct. This amount can surely be taken as representing what is to be gained from spraying alone without the aid of any other measures or methods.

It can be shown that the average yield in bunches from the Long Island fields the past year was between 750 and 800 bunches per acre. The records of the Canning Company also show that previous to the attacks of the rust the same fields yielded between 1500 and 2500 bunches per acre. It must not be assumed that from the fact that spraying gave an increased yield of 45 per ct. over unsprayed rows that the average yield of 800 bunches can be increased that amount. This percentage simply means that the yearly decrease in yield from the attacks of the rust can be reduced 45 per ct. Yet a study of Table III would indicate that there was an actual increase in yield of 14.5 per ct. from spraying.
THE PARASITIC DARLUCA.

In 1898, Dr. Halsted \(^{27}\) found a fungus known as *Darluca filum* Cast., which is a parasite upon many rusts, attacking asparagus rust.

This parasitic fungus has been so prevalent during the past two years that most growers of asparagus are familiar with it. Its abundance and the rapidity with which it spreads upon the uredo or summer stage of the rust has led others besides growers to anticipate remarkable benefits from its attacks on the rust.

During the past summer (1900) *Darluca* attacked the aecidial stage of the rust about June 10. Ten days later all the rusted asparagus stalks were covered with the *Darluca*. Notwithstanding the above condition, there was a severe outbreak of the summer stage of the rust on seedling beds about July 1, which was immediately followed by the *Darluca*. About the middle of August as severe an outbreak of the summer stage of the rust, as has ever occurred in previous years, appeared on the cutting beds. This in turn was followed by the *Darluca*. The same conditions were repeated again in September on the late watery shoots of asparagus. All of these attacks of the *Darluca* were followed by the formation of an abundance of the teleuto spores or winter stage of the rust.

Cross sections of the sori or rifts of the summer stage of the rust frequently show the condition illustrated in Fig. 2, Plate II, that is, the sori will be filled with the uredo or summer spores while beneath them a layer of the winter spores will be forming. We have even found sori in which the uredospores were apparently destroyed by *Darluca* while at the bottom of the sorus a layer of evidently healthy winter spores would be found.

The formation of the winter spores of the rust on the same plant where the uredo stage had been attacked by *Darluca*, combined with the conditions shown in Fig. 2, Plate II, all indicate that the *Darluca* attacks the spores of only the aecidial and uredo stages and does not injure the vegetative portion or that which answers as the root system of the rust. As yet it has not been shown that the *Darluca* ever attacks the thick-walled winter spores of asparagus.

spores. Hence the indications are that Darluca will not exter-
minate the rust nor even act as a material check especially where
asparagus is grown in large quantities.

Dr. Pammel\textsuperscript{a} states that Darluca has more delicate spores than
the rust and is more susceptible to the spray of the fungicide.

During the past three years no appreciable difference in the
amount of Darluca, on sprayed plants which had become rusted
and on unsprayed rusty plants, has been observed.

CONCLUSIONS.

All three stages of the asparagus rust occur in New York State.
The first stage is usually found on seedling and neglected beds
only. The uredo- and teleutospore stages can both be found on
the same plant at the same time whether it be June or October.
Furthermore both stages may occur together in the same rift or
sorus.

Cutting and burning too early in the fall is injurious. Late
burning admits of scattering of the spores, and combined with this
is the ever present fact of neglected fields and volunteer asparagus
as a source of infection; hence it is a question whether burning
is a profitable or even a practical method to follow in combating
asparagus rust.

Thus far no variety of asparagus has entirely withstood the
attacks of the rust in this State. In instances where one variety
has shown slight advantages it was questionable whether the
difference was not due to age or surrounding conditions instead
of to any inherent qualities.

Although Messrs. Stone and Smith assert that there is a
variation in the distribution and attacks of the rust due to differ-
ent soil conditions and that the uredo stage is limited to sandy
soils in Massachusetts, no such variations have been observed in
this State. Furthermore it appears from conditions found here
that the factor of fogs and dews may play a more important part
in the distribution of the rust than soil conditions.

The results obtained in 1898–99 show conclusively, not only
in appearance of the sprayed and unsprayed belts, but, also in
the yield, that spraying not only protected the asparagus from

\textsuperscript{a}Iowa Agr. Exp. Sta., Bul. 53, p. 64, 1900.
the rust but in addition was a source of profit. Nevertheless, the fact that the area used as a basis was small, allowing factors of error to be exaggerated, lessens the value of these results as a whole. Hence conclusions as to the value of spraying should not be based upon these alone. The resin-Bordeaux adhered fairly well and did not injure the asparagus in the least although the 1-to-8 formula was used in preparing the mixture.

Observation brought out the fact that only the growth made previous to the appearance of the rust on a field was protected by spraying; that is, a growth that was mature and thoroughly sprayed previous to the attacks of the rust. This observation applies only to the field where every other row was a source of infection. Furthermore it was observed that generally two and sometimes three periods of growth occur in Long Island asparagus beds, and for two seasons, 1899 and 1900, we have been unable to save these late growths on the test field. Hence the indications are that, even with spraying, the vitality of the sprayed rows on this field will be gradually reduced.

As already stated the resin-Bordeaux mixture caused no apparent injury to the asparagus. In fact no noticeable injury has resulted from the use of the resin-Bordeaux mixture, used as strong as 1 to 8 during three seasons.

It was found necessary to use between 250 and 300 gallons of the mixture per acre at each spraying when applied with a barrel pump. In addition it was ascertained that with an ordinary barrel pump with two leads of hose three men could not prepare the mixture and spray over three acres per day.

Thus far the results show that under the most unfavorable conditions a gain in yield of nearly 50 per ct. can be obtained by spraying while under more favorable conditions a gain of nearly 70 per ct. in yield can result from spraying. Expressing the results in values, under unfavorable conditions a gain of nearly 45 per ct. was obtained, while under more favorable conditions the gain was nearly 95 per ct.

_Darluca filum_ has been abundant on asparagus rust for two seasons and has been found attacking the rust in all its stages except the black or winter stage. Thus far no apparent checking of the injury caused by the rust, by the attacks of _Darluca_ on the rust,
has been observed; nor has any checking of the spread of *Darrua* by spraying been noticeable.

**RECOMMENDATIONS.**

Thus far the results obtained from spraying asparagus are marked enough to warrant the recommendation of spraying with resin-Bordeaux mixture in general as a means of controlling the asparagus rust.

It has been shown that on the test field, even with spraying, the rust destroyed the late growths of asparagus, with a consequent weakening of the plants. This in time would reduce the yield below a profitable point and spraying would only add to the expense of getting the reduced crop. Furthermore the work done brought out the fact that spraying asparagus thoroughly results in considerable expense and labor. Whether the cost of spraying can be reduced cannot be stated until after further tests have been made. Even without considering the latter factors it is evident that spraying alone will not wholly protect the crop. Whether varieties will be found which will resist the attacks of the rust entirely, or whether cultivation and soil conditions will prove a check to the attacks of the rust are factors still to be proven. Hence in consideration of all these facts, spraying should be undertaken with the determination of doing it thoroughly; and with the expectation that the rust will gradually reduce the vitality of the field even with spraying. Possibly the selection of those varieties which show some resistance to the rust combined with proper attention to cultivation and feeding of the crop, including the use of vegetable matters with the fertilizers used, will aid in preserving the vitality and do much toward obtaining better results from spraying.

Simply as an opinion, we will say, that by spraying twice a week we believe that young, rapid-growing shoots can be protected. That the apparent inability to get the mixture to adhere to them is due to the rapid growth of the plants, a factor which can be remedied by more frequent applications.

Spraying alone cannot be expected to be profitable on fields already reduced to one-third their original yielding capacity, nor can it be expected to revive such fields.
Basing a recommendation upon the results obtained combined with observation and experience in spraying of asparagus, we believe that it will pay all growers who have fields yielding 800 bunches and over per acre, to spray. In addition we would recommend the planting of corn on all sides of the asparagus field as a windbreak. Proper cultivation, fertilization and green manuring or supplying humus in some other form, follow as commonsense measures.

Where growers have a number of acres to spray we would recommend the construction of a power sprayer similar to the one described in Part II.

II. THE DOWNS' POWER ASPARAGUS SPRAYER.*

INTRODUCTION.

In the chapter on asparagus rust it has been shown that spraying asparagus is not an easy task. As has been stated, one of the reasons set forth as a factor against spraying asparagus, is the lack of suitable machinery for doing the work. It was also found to be a difficult matter for workmen to do the spraying by hand with the thoroughness necessary to make it of much value. In fact lack of thoroughness means complete loss of time and materials, for after the rust gains a foothold within the plant, spraying is of little value. Lack of thoroughness does not necessarily result from any intentional neglect on the part of workmen, but from the impossibility of always reaching all parts of a heavy row without drenching some of the foliage so that the liquid will not adhere. In the work for 1899 an outfit was used consisting of a barrel pump fitted with two leads of hose and requiring three men and a team to operate successfully. With this equipment three acres is all that can be sprayed in a day if the work be done with any pretense of thoroughness. Furthermore it was found that for full-grown, heavy asparagus between 250 and 300 gallons of Bordeaux mixture was required per acre, when applied by hand machinery.

*As it is impossible for the writer ever to repay Mr. Arthur L. Downs, not only for bearing part of the expense, such as furnishing wheels, tank and truck, for the power sprayer; but for aid furnished in designing and putting into working order the above named machine; it is proposed that this be known as the Downs' Power Asparagus Sprayer.
The expense is great in hand spraying, as a team and three men are required to spray three acres per day; and the labor involved in handling nearly 1000 gallons of liquid is not slight. The treatment must be repeated once a week for four or five weeks or oftener while the asparagus is growing rapidly; surely not an encouraging prospect for asparagus growers who have five acres and upwards; and especially, for those who grow from forty to sixty acres. In fact, with unfavorable weather, those with five or six acres would need to devote the major portion of their time to asparagus spraying, with a bare possibility of saving 40 per ct. of the crop.

The above factors, combined with the apparent success of our work in the fall of 1898 and of 1899, led to the designing and building of a power sprayer which it was hoped would do the work more thoroughly and rapidly than was possible to do by hand, the cost of the machine being a secondary matter. In order to secure efficiency the following conditions had to be met:

For economy in time the apparatus should have a tank capacity of at least 250 gallons; it must have a distributing capacity of that amount per hour, as a team walking at its normal rate will cover an acre of asparagus set in 6-foot rows in that time and thorough hand spraying requires 250 gallons of Bordeaux mixture per acre. The nozzles must be adjustable; as it is often desirable to spray the asparagus when small and as the rows on different beds are set at varying distances apart, from 4 to 7 feet. The free space between the rows will also vary with the age of the bed.

The mixture should strike the plant from all directions at the same time without having the jets of spray conflict. Theoretically with a machine which would stop an instant at each plant, this could be done by the employment of five nozzles to a row, but in a moving machine the resultant direction of the jets of spray requires the use of ten nozzles for efficient service. Later it was found necessary to use twelve nozzles to a row, especially on full grown, vigorous beds.

In addition to being adjustable it was desirable to be able to elevate the nozzles from between the rows when turning around at the end. It was found that thrifty plants, in rows six feet apart, nearly covered the ground, hence it was essential to devise
a means for lifting the asparagus before the spray reached it. This was necessary, not only in order to do the work thoroughly, but also to prevent tearing the nozzles from their carriers.

With all these conditions to be met the machine described and illustrated in the following pages was designed and built. As spraying may prove to be an aid to many growers in preventing the asparagus rust the following detailed description of the machine and its parts is given, with notes upon some of the weak points and suggestions for remedying them. The machine is not patented and it is hoped that growers may make use of the ideas and suggestions in the construction of machines of less cost, thus lowering the expense of spraying.

DESCRIPTION.

THE TRUCK.

Several conditions had to be met in constructing a truck. The height required to clear the asparagus is one factor. At first it was thought that this could be disregarded by constructing a narrow-tread machine which would go between the rows, but such a machine would be difficult to get through the rows of full grown asparagus, and could carry only a small weight of liquid. These considerations led to the abandonment of this scheme. The desirability of carrying a large amount of liquid, and the necessity of straddling the row led to the construction of a larger truck with arched axles which would clear the asparagus without injuring it. The sides of the arches were constructed of one and one-half inch square iron, the latter being bent at top and bottom. The top angles were flattened for attachment to an oak plate which formed the top of the arch, while the bottom angles formed the spindles for the wheels. The width of space at base of these arches is 4 feet 1½ inches while at the top this space is 3 feet 6 inches. The slant height of front arch to arch-plate is 2 feet 5 inches; slant height of rear arch to arch-plate 1 foot 10½ inches. Both arches were braced, each brace being 2 feet 6 inches long, made from inch iron. The arch-plate clears a space of 4 feet. The arrangement and sizes of parts of front truck are shown in Fig. 1, Plate VIII. As it would have been bad mechanics to draw all the load from one point at top of the front arch, especially with
PLATE VII.—GROUND PLAN OF ASPARAGUS SPRAYER.
PLATE VIII.—DETAIL PLAN OF FRONT TRUCK PUMP, CARRIER AND ARMS OF ASPARAGUS SPRAYER.
wheels which had a tread of 6 feet, a double-tree was attached to the pole and then connected with the axle of each fore-wheel so that enough of the load was drawn from the latter points to remove all side wrench on the arch. See Plate XI. The arch-plate of rear arch forms part of the whole framework and is shown in Plate VII. The tool box is shown only in photographs.

With the exception of the brake-bar, the 2x4 inch cross plate at rear of frame, and the 2x3 inch diagonal plates which support the carrier, all the wood parts are of oak. The brake-bar, the diagonal carrier-supports, and the cross plates on which the latter rests, are of pine. A clear space of 2 feet 11 inches was allowed between the side plates. At points i i i, Plate VII, three half-inch iron plates are attached for carrying the upper half of the fifth wheel and serve as partial supports for the tank. Across the rear end an oak plank 14 inches wide was bolted to side-plates as a support for the pump. In addition a second plank shown in Plate VII was bolted to the above cross plank and to rear arch-plate for attachment of fulcrum to clutch-brake. The lengths and sizes of timbers are as shown in Plate VII.

The wheels are iron, having 4-inch tires, one-half inch thick, and guaranteed to carry from 8,000 to 12,000 lbs. The rear wheels are 50 inches in diameter. The fore-wheels are 40 inches in diameter. They were obtained of the Electric Wheel Co., Quincy, Ill.

TANK.

A half-round tank was obtained from Thompson, Habmar and Fisher, Tonawanda, N. Y. It is made of 1 3/4 inch cypress, the top cross plates being 2x5 inch oak. Dimensions 6 feet by 2 feet 9 1/2 inches by 1 foot 9 inches, capacity 250 gallons.

GEARING.

The pump is geared to the left hind wheel by means of chains combined with a shaft and four sprocket-wheels. The large sprocket-wheel, which is attached to the truck wheel, has a diameter of 25 inches and bears 49 teeth. The small sprocket-wheel on end of shaft is 8 1/2 inches in diameter, and has 16 teeth. The large sprocket-wheel on shaft has a diameter of 17 inches and carries 32 teeth. The small 8-toothed sprocket-wheel on crank
shaft of pump has a diameter of 5 inches. A "clutch-gear" is attached to large sprocket-wheel on shaft. The size of chain used is No. 45.

PUMP.

The selection of a pump was not an easy matter. It was necessary to have a pump that would throw at least 300 gallons per hour. Rotary pumps would meet the above requirement, but these have usually been found short lived when used for pumping Bordeaux mixture. The addition of the resin solution is hard on single plunger brass pumps and would make matters worse in the case of rotary pumps. No manufacturers of single or even double-plunger brass pumps would warrant their pumps to throw 300 gallons per hour, nor could any of them tell how high it would be necessary to speed such a pump to make it throw the required amount.

It was finally decided to test a single-acting triplex pump made by the Gould Manufacturing Company, Seneca Falls, N. Y. This pump was scheduled to make 50 revolutions per minute and throw 360 gallons per hour. It had the disadvantage of having the water-box constructed entirely of iron; only cylinders, glands and plungers being of bronze or bronze lined. As manufactured these pumps are geared back 5 to 1. All the gearing was removed and a small sprocket-wheel attached directly to crank shaft. This pump had the advantage over single-cylinder pumps of maintaining a nearly constant pressure without the aid of an air chamber. The position of the pump and the method of connecting with tank and carrier are shown in Fig. 2, Plate VIII.

CONNECTIONS.

The pump used had 1 3/4 inch suction and discharge hence 1 3/4 inch connections were used throughout. The method of connection and arrangement of parts is shown in Fig. 2, Plate VIII. The use of a style of shaft and gearing given later would permit of the pump being placed nearer the tank and the use of shorter nipples. The distance between the first gate-valve and lock-nut connecting to tank is 7 1/2 inches. The gate valve, also the Ts, are standard trade lengths and sizes. A T, with valve connections as shown at k, Fig. 2, Plate VIII, was placed next to
the pump for two purposes. It is desirable to run clean water through the pump without having to run it through the tank. Furthermore it was necessary to arrange to drain the pump from both sides. This \( \mathcal{T} \) and gate valve also allow of emptying the tank through the suction pipe.

A shut-off valve was placed in main supply pipe at \( uv \), for the purpose of maintaining the pressure when the machine is stopped, also to hold the liquid in the carrier. This proved to be of little

EXPLANATION OF PLATES.

**PLATE VII.** *Ground plan of power sprayer showing arrangements of parts except tool box.*
*Drawn to scale of one-half inch to the foot.*

**PLATE VIII.** *Fig. 1.—Ground plan of front truck.*

**Fig. 2.—Diagram of pump with connections to tank and nozzle carrier. Arrows indicate direction of flow also points of connection to other figures.*

**Fig. 3.—Diagram of one-half of carrier, rear view, showing arms.*

**Fig. 4.—Diagram of side view of arms and vertical supply pipe. All parts except arms drawn to scale of one-half inch to the foot.*

**PLATE IX.** *Rear side view of sprayer showing arrangements of parts of carrier and rakes with their supports.*

**PLATE X.** *Same as Plate IX with carrier elevated to show parts more plainly, especially attachment of brake bar to carrier and horizontal supports, together with anchorage to side.*

**PLATE XI.—Side view of carrier and rakes elevated, side view of pump showing sprocket, also connection with shaft. In addition showing side view of arches with their braces.*

**PLATE XII.—Machine at work in field spraying two rows at a time.*

value. A \( \mathcal{T} \) was used in connecting main supply pipe with pump for the purpose of attaching a pressure valve and return overflow pipe. At the same time the latter valve was used as a means of draining the outer side of the pump and the main supply pipe. A power pump should be so geared that it will give good pressure no matter how slow the team moves, hence the necessity of a pressure valve to allow of pumping back into the tank when the speed of the machine is increased. The pressure valve and return overflow pipe, with connections, are 1 inch.
PLATE IX.—REAR VIEW OF SPRAYER.
PLATE XII.—SPRAYER AT WORK.
NOZZLE-CARRIER.

All the foregoing parts are simply necessary means to an end, which any mechanic unfamiliar with spraying could easily have designed. The most difficult problem of the whole machine to work out was the nozzle-carrier. In order to do the work thoroughly it is necessary for the spray to reach the plants from all directions.

In a moving machine this must be accomplished by arranging the nozzles to spray forward and backward from above and diagonally forward and backward from the sides at both top and bottom. At the same time provision must be made for treating rows set different distances apart, also of varying widths, and asparagus of different sizes and for elevating the nozzles when turning at the ends of the rows. The whole problem was finally solved by the combination of union joints allowing shear motion, and telescoping joints. The union joints are useful not only in allowing of a shear motion but also to give direction to the nozzles.

At first it was thought necessary to have the telescoping joints of ground tubing, and a carrier was constructed on this principle. By trial it was found that ordinary iron sizes of brass tubing, such as are handled by the trade, could be packed tightly enough to prevent leakage and answered the purpose better than ground tubing, as joints made with the latter soon became so gummed with the resin solution as to be nearly immovable. The essential parts of this nozzle-carrier are shown in Figs. 3 and 4, Plate VIII, and most of the parts are self-explanatory. Fig. 4 connects with Fig. 3 by means of a T shown at g. Fig. 3 shows one-half of the carrier and connects with main supply pipe, Fig. 2, at y. The number and arrangement of the nozzles are shown in the various photographs which illustrate the machine as a whole in different positions and at work. All the parts with which the Bordeaux mixture comes in contact are constructed of brass. The unions are brass with ground joints and those shown at u, Fig. 4, which allow of the shear motion of the arms, are fitted with set-screws to prevent unscrewing of the union. The horizontal lengths of pipe shown in Fig. 3, were cut approximately two feet long. The horizontal telescoping joints allow of closing the carrier for four foot rows, or of extending it for seven foot
rows. The lengths of pipe which form the vertical supply pipe, shown in Fig. 3 and Fig. 4, also those which form the arms, were cut approximately 18 inches long. The telescoping of the arms combined with the shear motion is an essential feature in adjusting the nozzles for different heights and widths of rows. It is still an open question whether the vertical telescoping joints shown at \( j' \) are of any real merit. One point is certain, the use of a telescoping joint in the vertical supply pipes which carry the arms necessitates extra fixtures and adds to the weight. The rods shown at \( r \), Fig. 3, were provided to prevent twisting and slipping of the arms on the above joints, but as these proved more ornamental than useful for this purpose, an iron bar, shown at \( b \), Fig. 4, was added. The latter prevents the twisting; it also strengthens the leverage for lifting the arms when turning around; at the same time it prevents sliding of the vertical joints. By the use of the above bar, the rods shown at \( r \), Fig. 3, are not essential.

At first the elbow put out with the "Erin" nozzle by the Gould Manufacturing Company, was used for attaching the nozzles. These proved to be too weak for practical use so were abandoned and eighth-inch ground brass unions substituted. By the use of a short piece of bent tubing these unions gave nearly as much freedom of direction as did the elbows. At the same time the unions would turn before breaking or wrenching off, but could be screwed tight enough to hold the weight of the nozzle.

The size of tubing used in arms was one-eighth inch, telescoping into one-half inch, iron pipe sizes. The vertical supply pipes consisted of one inch pipe telescoping over three-fourths inch pipe. The latter is not iron pipe size. The same dimensions were used for the horizontal telescoping sections. The use of one-eighth inch tubing at end of arms together with one-eighth inch \( \Gamma \)'s and unions necessitated bushing the nozzles. The arms are adjusted, with regard to position, by means of a sliding sleeve attached to the vertical supply pipe. The motion is conveyed by means of adjustable levers which connect with a clamp on each arm. The sleeve is held in position by means of collars provided with set-screws.
It has been stated that the utility of the telescoping joints in the vertical supply pipes carrying the arms, is doubtful. This does not apply to any of the other telescoping joints. The horizontal telescoping joints not only allow of contraction and extension of the carrier for rows set different distances apart but also serve the purpose of a hinge joint when the arms are lifted for turning around. Those of the arms not only allow of lengthening of the arm but also prevent breaking or wrenching of the carrier when nozzles are caught in the asparagus. This results not only from the ability of the joint to twist but also to pull out entirely, yet the joint can be packed firmly enough to prevent leakage and shaking or falling out. In fact, the combination of telescoping and union joints answers the purpose of ball and socket, or universal joints.

The method of attachment of carrier to pump is shown in Figs. 2 and 3. This connection serves as a partial support. The carrier also rests upon the horizontal supports connected with framework of truck as shown in Plate X, and upon an iron brace shown at b', Plate VIII. The same parts are shown in the various other illustrations. In addition it is anchored at points b, b', Plate VIII. These not only help to hold and steady the carrier but also serve as guides when lifting and adjusting the parts.

The brake for lifting the arms is anchored to the cross of the main supply pipe at x, Fig. 3, Plate VIII, while the brake bar is attached to lateral supply pipe as shown in Fig. 4, o, also in Plate VII, o. The work of this brake is shown in Plates X and XI.

It will be seen that the carrier of this machine is so constructed that after the first round it sprays two rows at a time, or, rather it sprays one row completely and one side each of two other rows. The reasons for constructing the carrier in this way was, first, that it makes a balanced piece of apparatus. Second, with a heavy machine, carrying such a weight of liquid it was desirable to cover as many rows at a time as possible. When it was desired to spray a single row caps were placed on the ends of the outer telescoping tube of the outside arms.
LIFTERS.

Another feature, and one that was found necessary after the machine had been put in working order, is the lifters or rakes. These were found indispensable not only as a protection to the carrier arms but also to lift the asparagus so that it could be sprayed to better advantage. It is essential that the lifters should be adjustable, hence the principle of telescoping was again employed. It was found that rake teeth would injure the asparagus the least, be the least in the way, and add the least amount of weight. Two teeth were employed for each pair of lower nozzles. As shown in Plates IX and X, they were attached to horseshoe shaped pieces of iron, one tooth being set ahead of the other; the object being to have the forward tooth partially lift the asparagus, the rear one to lift it still higher and hold it until the nozzles had passed. The horseshoe shaped irons were attached to ordinary iron pipe, the latter serving as an attachment bar, the sizes being 1 and 2 inches. This bar was anchored to the rear end of the side plates of the truck. A brake for lifting the rakes was attached as shown in Plate X, and so weighted that when released it would lift the rakes.

The teeth for this lifter should be made to order. Old rake teeth were used as a trial but tempering of them to secure the right shape spoiled them so that they either bent out of shape or broke off.

COST.

Changes which had to be made, trying different styles of elbows and unions, testing different sets of nozzles, together with an accident to the carrier, and the extra work required to put parts together the first time, brought the cost of this machine nearly to the $300.00 mark. At the outside the parts ought not to cost more than as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheels</td>
<td>$16.00</td>
</tr>
<tr>
<td>Tank</td>
<td>12.00</td>
</tr>
<tr>
<td>Pump, iron triplex</td>
<td>85.60</td>
</tr>
<tr>
<td>Gearing and shafting</td>
<td>15.00</td>
</tr>
<tr>
<td>Material and building of carrier including connections to pump and tank</td>
<td>50.00</td>
</tr>
<tr>
<td>Material for framework and putting all the parts together</td>
<td>50.00</td>
</tr>
</tbody>
</table>

Making a total of $228.00
A triplex bronze pump can be made to order for $40.00 additional. We believe that the actual cost of building can be reduced to $200.00.

CONCLUSIONS.

When completed and tested the machine proved much less unwieldly and awkward than appearances would indicate. It could be turned in a space of six feet, not including team. All the joints were easily packed to prevent leaking, and, the raising and lowering of the carrier in turning did not cause the horizontal telescoping joints to leak. It was thought that it would be impossible to use it in asparagus fields that were on sand beds, nevertheless a span of fourteen hundred pound horses handled it with but little extra effort on level ground where the wheels sank four inches into the sand.

Tests showed that an acre could be sprayed in less than an hour, doing the work more thoroughly than could be done by hand. Furthermore, there was a saving of material, as between 150 and 175 gals. was all that was used per acre—when all the parts worked perfectly. When many stops had to be made considerable material was wasted as it was impossible to hold the liquid already in the arms and supply pipe.

As a whole, the machine exceeded our expectations, and in fact met all the requirements of an ideal sprayer. In building another the only changes that would be made would be in size and weight of some of the materials used.

Finally, it is not advised that any one grower should go to the expense of building such a machine to spray five or six acres of asparagus. The grower of 15 acres or over could well afford to do this. A better way would be for several growers of asparagus to combine in building such a machine; or, one person could build such a machine and do spraying for his neighbors as a business, the same as threshing is done. It is believed that a similar machine can be build for less than $200.00.

RECOMMENDATIONS.

For those who may wish to construct a similar machine, the following suggestions and recommendations are given: Possibly by the use of T iron for making the arches their weight could be reduced. We found that the cross-plates on forward truck were
too light, being 2x3 in., and would recommend that the two cross-plates be made of same sized timbers as the arch-plate, namely, 3½x4½ in. We would also recommend the use of 2½x4½ in. side-plates instead of 4x4½ in. plates. These would support the weight of tank as well as the 4x4½ inch plates and reduce the weight of the truck as a whole.

The advice of the Wheel Company was taken and heavy thresher wheels used on rear axle. These were heavier than needed. The ordinary weight of wheels, such as furnished by the Company for farm wagons, would have answered the purpose as well.

The advice of the Link-Belt Company was also taken regarding shafting; as a result a shaft one and fifteen-sixteenth inches in diameter was used. This is nearly twice as heavy as required. The use of a sprocket-wheel on the right rear-wheel larger than that used on the Down's Power Asparagus Sprayer, and swinging a shaft, 1 in. in diameter, over the right-hand side-plate, would allow a smaller sprocket wheel on the outer end of the shaft, also a smaller one on the inner end next to the pump. In fact the latter could be small enough to be placed directly under the small sprocket-wheel on crank-shaft. In this way the pump could be placed nearer the tank, shorter chains could be used, and thus the weight of all the shafting and gearing be reduced nearly two-thirds.

The weight could be reduced slightly by placing the elbow, which follows the safety-valve, next the T and placing the safety-valve beyond the elbow.