NEW YORK AGRICULTURAL EXPERIMENT STATION.

GENEVA, N. Y.

COTTONWOOD LEAF BEETLE.
GREEN ARSENITE.

V. H. LOWE.

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*Connected with Fertilizer Control.
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I. THE COTTONWOOD LEAF-BEETLE.

II. GREEN ARSENITE.

SUMMARY.

During the past four years the growers of basket-willows in central New York have suffered serious loss from the depredations of the cottonwood leaf-beetle.

In both the larval and the mature stages, the insect attacks the willows, feeding upon the young leaves and tender bark near the tips. This injury to the tips causes the willow "whips" to branch, thus rendering them worthless for basket-making purposes.

It lives above ground during all of its transformations. The eggs are laid upon the leaves and the larvæ feed upon the more tender tissues. The pupæ are attached to the under sides of the leaves or to the bark. The mature insects, beetles, are active and fly readily from one field to another. The winter is passed in the adult stage, the beetles seeking shelter under stones, logs or any convenient rubbish.

On the experimental field the willows were successfully protected by three applications of green arsenite, 1 pound to 100 gallons of water.
Green arsenite is a simple arsenite of copper similar in texture and chemical composition to Scheele's green. It is as poisonous as Paris green, is cheaper to manufacture, and is an impalpable powder instead of crystalline, hence it will remain suspended in water longer than ordinary Paris green thus insuring a more even application to the foliage. It should be used with lime in the same manner as Paris green.
THE COTTONWOOD LEAF-BEETLE.

*Lina scripta* Fab.

INTRODUCTION.

The industry of growing basket-willows in central New York has been seriously handicapped by an insect known among willow growers as the "willow beetle," but among writers on economic entomology as the cottonwood leaf-beetle. It is a species which, previous to 1894, attracted but little attention in the east, although it has long been known as a serious pest to cottonwood in the middle and western states. Since the winter of 1893-94 this insect has been very abundant in this State, especially in Onondaga County, doing great damage in the willow fields about Syracuse and Liverpool.

The investigations and experiments reported in this Bulletin were undertaken at the urgent request of some of the leading willow-growers of the State. The life-history and habits of the insect were studied only during the several visits made to the infested fields as no suitable place for breeding the beetles at or near the Station was available. The experiments cover a period of two years and were undertaken with a view to determining, if possible, a satisfactory method of protecting the willows from serious injury by this insect.

GENERAL NOTES UPON THE BEETLE.

CLASSIFICATION AND NAME.

This species is classified with the large and economically important group of beetles scientifically known as the *Chrysomelidae*. 
This group includes the leaf-eating beetles and among them are found some of the most pernicious of the insect pests.

Probably because this insect first attracted most attention as an enemy to the cottonwood, it was given the name of "Cottonwood Leaf-beetle" or the "Streaked Cottonwood Leaf-Beetle." In this State, however, it is little known excepting as a pest to basket-willows and hence is known among willow growers as the "Willow Beetle" or incorrectly "The Willow Bug." The scientific name, "Linnaeiscripta" was given the species by Fabricius.

ECONOMIC IMPORTANCE.

Fortunately this insect does not have a wide range of food plants or it would doubtless have become of much more economic importance than it is. Where cottonwoods, poplars or willows are extensively grown, however, it may become a very serious pest. In the Dakotas, Nebraska, Kansas and Missouri, the insects appear in great numbers, stripping the leaves from large areas of these trees thus causing serious injury throughout the districts where trees of this kind are valued for timber.

In this State the insect is a serious pest to one of the small, but important industries. Probably the greatest injury was during 1894 and 1895. In Onondaga County where basket-willows are extensively grown, from half to three-fourths of the crop was rendered worthless. In the vicinity of Liverpool alone, the crop was estimated to be about 1,200 tons less in 1895 than in 1894, the shortage being caused by the beetles. As a further example one farmer near Liverpool who grows 20 acres of willows, which yield under ordinary circumstances about 5 tons per acre, bringing from $16.00 to $40.00 per ton, harvested in 1894 only about $200 worth of marketable willows, and the following year his returns were but little better. This is but one of many cases of the kind that might be mentioned to show the serious injury which this insect is capable of doing. Fortunately the beetles were somewhat less abundant during 1896 and 1897.

1Identified by Mr. E. A. Schwarz.
IMPORTANCE AS A PEST TO NURSERY STOCK.

As a rule the cottonwood leaf-beetle does but little injury in the nursery, especially in the east. There have been a few instances, however, where the beetles have appeared in eastern nurseries in sufficient numbers to do serious injury. One of the most important of these is recorded in *Insect Life* by Mr. Thos. B. Meehan who states that the "willow beetle" did serious injury in his nursery at Germantown, during the spring of 1887, to Carolina poplars and Kilmarnock and New American willows.

In this State, the only instance of injury to nursery stock by this insect which has come under the writer's notice was in the nurseries of the Smiths & Powell Co., of Syracuse. In 1895 and 1896 the beetles did serious injury in a few blocks of Carolina and Norway poplars. They were especially injurious during the spring of 1896, threatening to ruin all of the Norway and Carolina poplars in this nursery.

HISTORY AND PRESENT DISTRIBUTION.

The original home of the cottonwood leaf-beetle is not positively known.

In this country, it did not attract much attention until about 1876. In 1877 and 1878 the beetles did serious injury to cottonwood in the prairie states, especially Dakota, Kansas and Nebraska, where the cottonwood is valued for both ornamental and commercial purposes. In 1884 the cottonwoods in these sections were again seriously injured by the beetles which, it is said appeared in swarms, quickly stripping the trees of their leaves.

On the authority of Dr. C. V. Riley the habit of feeding on cottonwood was acquired long after the species was known as a pest to willows and he suggests that "a special cottonwood feeding race of the species has of late years been developed."

The cottonwood leaf-beetle occurs throughout the United

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1: 51.
States, and according to Mr. E. A. Schwarz in a recent letter to the writer, is found as far south as the City of Mexico. It is best known as an injurious species along the Mississippi Valley.

In this State it is little known outside the willow-growing districts. It first attracted the attention of the willow-growers in 1875 when more than 50 acres of willows in Onondaga County were practically destroyed. From that time until 1893 the beetles did not appear in sufficient numbers to do serious injury. In the spring of 1894 the beetles appeared in swarms throughout the willow-growing sections of the central part of the State, greatly reducing the yield of marketable willows. During 1895 and 1896 there was no apparent decrease in the number of beetles and the injury to the willows was not lessened. In 1897 the beetles were somewhat less numerous, but still sufficiently abundant to do great injury to the willows.

Although widely distributed throughout the State, the distribution of the species as a seriously injurious pest is practically limited by Oneida, Madison, Onondaga and Cayuga Counties. Although basket-willows are grown commercially in at least eight counties west of Cayuga, the beetles have not been found in sufficient numbers to do serious injury.

FOOD PLANTS.

The principal food plants of this species are willow and cottonwood. It has also been found upon the box-elder.

HOW THE WILLOWS ARE INJURED.

The nature of the injury caused by the beetles will doubtless be better understood after a brief explanation of the method of growing basket-willows. The principal species cultivated is the European osier, *Salix viminalis*. As previously stated by Dr. Lintner the willows are propagated by cuttings. These cuttings are nine inches in length and are set six inches into the ground, and about fourteen or fifteen inches apart in rows about three feet apart. The young willows grow rapidly, a good growth

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4New York State Entomologist Rept. 1895: 185.
averaging from five to six and one-half feet in a season. They are large enough to cut the second year, but produce only about two tons per acre, and may continue to yield good crops for from ten to fifteen years. By November the willow-whips are ready to cut, the old stubs being left to produce the next year's crop.

It is the object of the grower to produce a tall, straight but flexible growth about one-eighth of an inch in diameter at base, and measuring from five to nine feet in height. The injury caused by the beetles is not so much the weakening of the plant by loss of foliage as by the branching of the willow-whips which results from the injury to the rapidly growing tips. The beetles which have lived over winter are astir early in May and feed for two or three weeks. They attack the young willows vigorously, feeding largely on the new growth, thus causing the tips to wilt and die. Frequently the entire tip is eaten off. In this manner irreparable injury is caused at the beginning of the season. Plate I is from a photograph showing a bunch of young willows with injured tips. Plate II is from a photograph of a normal willow whip and one which was injured early in the season in a manner similar to those shown at Plate I. At a the willow was eaten off or sufficiently to stop the growth, thus resulting in the sprouts and consequent worthless willows as these sprouts never become long enough for basket-making purposes. The uninjured willow is shown on the left.

The injurious work begun by the beetles is continued by the larvæ and adults of the next brood, and as these are much more numerous and appear at a time when the willows are growing at their best, the injury is much greater.
DESCRIPTIVE DETAILS.

DESCRIPTIONS AND LIFE-HISTORY.

Appearance in the spring.—The beetles which have lived over winter come forth from their retreats during the latter part of April or early in May. In the vicinity of Syracuse they are usually first seen from the first to the tenth of May. As previously stated the beetles feed voraciously on the new growth, preferring the tender bark, but also feeding upon the leaves, and frequently devouring the young shoots before they have fairly started.

The egg.—Egg-laying begins about the tenth to the fifteenth of May and may continue for a week or more. The eggs are deposited in groups, usually on the under surface of the willow leaves, but they were frequently found upon blades of grass or leaves of weeds growing in the willow rows. Each egg is firmly fastened on end to the leaf and usually in a slightly slanting position as shown at Plate III, on the left of fig. 1. These groups vary in the number of eggs contained. In about fifteen examined the number varied from 25 to 52. The average number is about 45.

The eggs are light lemon-yellow in color turning to a deep salmon just before hatching. They are elongate-oval in outline and vary in size from 1.35 mm. by 0.63 mm. to 1.47 mm. by 0.84 mm. The shell is smooth, thick and leathery.

Period of incubation.—The period of incubation is usually from ten days to two weeks. This was the period for 1894, 1895 and 1896. Last spring was an exception as few of the eggs hatched within twenty days.

The larva.—When first hatched the larvae measure from 1.05 mm. to 1.11 mm. in length. The diameter of the head is 0.6 mm. and that of the body 0.54 mm. on the anterior half tapering to 0.21 mm. at the last abdominal segment. The entire body is black or very dark brown. When full grown they measure, on an average, about 8 mm. in length. The width of the head is 0.75
mm. and of the body, on the anterior half, 2.5 mm. tapering to about 0.6 mm. on the last abdominal segment. The body is of a dirty yellowish color, the head a dark brown and the legs black. A double row of dark brown spots, two on each segment, extends along the upper surface of the abdomen. In a line with these is a row of black tubercles on each side which, when the insect is disturbed, emit drops of white milky fluid, of a strong pungent odor, which may be drawn back when the threatened danger is past. Two tubercles, nearly white with dark colored tips, are conspicuous on the lateral margins of the first two abdominal segments. At the tip of the abdomen is a disc covered with a sticky substance which is used both as an aid in crawling about and to hold to the support when necessary. This is especially true with the newly hatched larvæ. Its chief office, however, appears to be as a means of attaching the larvæ to the leaf when about to pupate and to hold the suspended pupa until the beetle emerges. The larvæ are mature in about two weeks.

Habits of the larva.—The newly hatched larvæ remain for a few hours crawling about over the empty egg shells, but soon settle down in the immediate vicinity and begin gnawing through the epidermis to feed on the soft tissues beneath. They feed side by side for three or four days, finally separating to feed independently on different parts of the leaf. As they grow older and stronger they devour the entire leaf with the exception of the midrib and larger veins. Plate III, fig. 1.

In several cases under observation the eggs had been placed on old leaves and the young larvæ, not finding tender food, migrated to the tips of the shoots to feed on the tender leaves and bark thus causing the same injury as the beetles.

The larvæ are full grown in from ten to fifteen days and, after remaining comparatively inactive for a day or two, prepare for pupation. Plate III, fig. 2, is from a photograph of a larva, natural size, and enlarged.

Pupation.—Pupation takes place above ground. When about to pupate, the larva attaches itself to the leaf by means of the sticky disc at the tip of the abdomen and allows its body to hang down. The head is gradually bent forward and the legs drawn up to the body. The transformation from the larva to the pupa
takes place in a few hours. The pupa is retained in the larva skin.

The pupa.—The pupae are familiarly known among the willow pupated growers as "hangers." Usually all of the first brood have by June 10. The pupae are attached promiscuously to the under surfaces of the leaves, usually upon the upper half of the willow or upon blades of grass or weeds growing in the willow rows. They are shining black on the anterior half and dark brown on the posterior. They vary in length but measure on the average, when first formed, about 9 mm. and are about one-third as broad on the anterior half, tapering from the middle to the posterior extremity. Plate III, figs. 3 and 4.

As the time approaches for the mature insect to come forth, the outline of the pupa becomes more distinct. The posterior half which becomes an empty skin, shrivels and the true pupa stands out prominently. It is oval in outline, more or less obtusely rounded at each end, and measures about 6 mm. by 3.5 mm. The pupa stage lasts from ten days to two weeks.

The mature insect.—The mature insects, beetles, vary in length from 5 mm. to 8 mm. and are a little more than half as broad as long. The general color is black and gold above and dark metallic green beneath. The head and thorax are black, the latter having broad lateral margins of brick red partially interrupted at the middle by a more or less distinct black mark. The elytra are marked with black and gold, the black being in three interrupted longitudinal lines on each elytron. The lateral and posterior margins are brick red. The inner margins are black and when the elytra are at rest form a broad, median line of black. The other markings on the elytra vary. In some individuals the gold predominates, while in others the black is more prominent.

The legs are brick red and black, the former color usually prevailing on the posterior third of the femur and the anterior two-thirds of the tibia. The tarsi are marked more or less regularly with brick red and black. Plate III, fig. 5, is from a photograph showing the mature insect natural size and enlarged.

The beetles or "hard shells" as they are commonly known among willow-growers, are most numerous on the willows, about
Syracuse, from the middle or latter part of June until the second or third week in July. During this time the willows grow rapidly, about three feet being a fair growth, and as the beetles feed voraciously on the tender leaves and bark at the tips of the willow-whips irreparable injury is done by causing them to branch as previously explained.

_Hibernation._—By the first of August nearly all the beetles have left the willows and sought shelter in any convenient place. In the fields about Syracuse they could occasionally be found under stones but were more numerous under logs, under bark on trees and in the crevices in fence rails. In willow fields which have not been kept free from weeds and grass, the beetles find shelter down close to the roots or in the stools of grass. In these retreats they remain until the following spring.

**NUMBER OF BROODS.**

There are probably two broods and possibly three, but this point has not been satisfactorily settled. The writer failed to find eggs later than June 24, and as the beetles retreat to winter quarters early in August, there is hardly time for more than two broods under the most favorable circumstances.

**NATURAL ENEMIES.**

Several species of *Coccinellidae*, lady-bird beetles, and *Carabidae*, ground beetles, are said to attack this insect in the undeveloped state. The eggs especially are devoured by the lady-bird beetles. Dr. Riley⁵ states that he has observed a species of *Coccinellidae*, _Megilla maculata_, feeding upon larvæ and pupæ of this insect. Doubtless these natural enemies have been more or less active in the willow fields about Syracuse, but the writer did not observe an instance of this kind on any of the visits to the fields, and of several growers questioned, none had seen the predaceous insects.

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⁵Insect Life, 3:43.
METHODS OF COMBATING.

The principal methods employed by the willow-growers of this State in combating the cottonwood leaf-beetle may be classified under two heads:

(1) The application of poison or repellents to the willows, either dry or mixed with water.—The poisons most commonly used are Paris green and London purple, applied either in water or mixed with lime or land plaster. Paris green and land plaster, about 1 part of the poison to 40 parts of land plaster, is considered an effectual remedy if applied when the willows are wet with dew or rain. A solution of copper sulphate without lime, 1 pound to from 7 to 12 gallons of water has been tried by several growers about Liverpool, one of the willow-growing centres near Syracuse, but without much success. If applied strong enough to materially check the insect, it injures the willows.

None of the above compounds have proven uniformly satisfactory in the hands of the willow-growers.

(2) By using machines for catching the beetles.—These machines are made for use with either horse or hand power. The two forms are illustrated at Plates IV, V and VI which are from photographs taken by Mr. Rogers of Liverpool, at the writer’s request. The dimensions of the body of the horse-power machines are as follows: Length 5 ft., width of rear end 2 ft., front end 1 ft. 8 in., depth 6 in. The body thus forms a shallow tank which may be lined with zinc or tin and in which kerosene oil or kerosene oil and water, the oil forming a thin film on the surface of the water, should be kept while the machine is in use. A number of narrow strips are placed longitudinally over the top in the manner shown in Plate IV to keep the willows from touching the oil. Two stout runners fastened to the under side support the tanks. Plate V shows the machine in position ready for use. As will be observed, it is made to run between the rows; the long arms which extend obliquely from either side, cause the willows to bend over as the machine moves along and at the same time rub off the beetles and many of the larvæ and pupæ which drop into the tank and are quickly killed by the oil. A lighter machine for hand power is shown at Plate VI.
Of the two classes of methods used in combating this insect, the latter has proven much more satisfactory; but unfortunately owing to the small size of the willows, the machines cannot be used to advantage early enough in the season to prevent serious injury by the beetles which first appear in the spring and also by the young larvae as they are not as readily dislodged.

In order to ascertain if possible whether the insect could be satisfactorily held in check by the application of an arsenical poison, thus providing a way to stop the injury to the willows early in the spring before the machines can be used to advantage, the following experiments were undertaken.

EXPERIMENTS.

The experiments were continued through two seasons, beginning in the spring of 1896. Through the kindness of Mr. Joseph Kennedy, of Liverpool, N. Y., a field of about an acre of willows on his farm was reserved for the experiments. Green arsenite and arsenate of lead were the poisons selected the first year as being most likely to prove satisfactory.

The green arsenite was used at the strength of 1 lb. to 150 gals. of lime water and the arsenate of lead, 1 lb. to 45 gallons. For the first spraying on two of the plats, 2 qts. of glucose was added to each 45 gals. of the mixtures and for the second spraying the same amount of thin glue.

The treatment which each plat received the first year is shown in the following diagram:

**Diagram of Plats in 1896.**

<table>
<thead>
<tr>
<th>Dates of sprayings</th>
<th>Plat I.</th>
<th>Plat II.</th>
<th>Plat III.</th>
<th>Plat IV.</th>
</tr>
</thead>
</table>
Experiments in 1896.—As shown in the table, the plats were sprayed but twice in 1896. Unfavorable weather prevented a third spraying until too late to be practicable and the machines for catching the beetles were used twice, about seven days apart, after the last spraying. For these experiments a knapsack sprayer was used to apply the poison. When lime was used, enough of the freshly slaked lime was added to make the mixture slightly milky in appearance.

Results in 1896.—It was difficult to obtain exact results in this case. Swarms of beetles came from other fields to the sprayed plats. The general indications were that the plats sprayed with green arsenite mixed with lime water and glue and with arsenate of lead and glue were less injured after the second spraying than the other plats. About 80 per ct. of the willows on these plats were uninjured by the beetles, while on Plat III, the check plat, at least 50 per ct. were damaged. Glucose did not prove as successful in making the mixture adhere to the leaves as thin glue, but glue was found to be impractical for this purpose because of sticking in the pump and clogging the nozzle.

Experiments in 1897.—The plan of the experimental field was changed for these experiments and a Peppler horse-power sprayer used in place of a knapsack. As shown by the diagram the acre was divided into two equal plats and both plats sprayed on June 3.6 The machine for catching the insects was not used on either plat. Plat II received but one application of the poison while Plat I was sprayed as shown in the following diagram.

The green arsenite was used at the strength of 1 lb. to 100 gallons of lime-water. Whale oil soap, 1 lb. to 20 gallons of the mixture, was added to make it spread upon the leaves. Whale oil soap also doubtless acts as a repellent to the insects and may be used much stronger.

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6 The original plan was to leave Plat II unsprayed but through a misunderstanding it received one application of the poison.
### Diagram of Plats in 1897

<table>
<thead>
<tr>
<th>Dates of spraying</th>
<th>Plat I</th>
<th>Plat II</th>
</tr>
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<tbody>
<tr>
<td>June 3.............</td>
<td>Green arsenite and</td>
<td>Green arsenite and</td>
</tr>
<tr>
<td></td>
<td>whale oil soap.</td>
<td>whale oil soap.</td>
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<tr>
<td></td>
<td>Same.</td>
<td>Untreated.</td>
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<tr>
<td>June 13...........</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Same.</td>
<td>Untreated.</td>
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<tr>
<td>June 23...........</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Results............</td>
<td>Marketable willows,</td>
<td>Marketable willows,</td>
</tr>
<tr>
<td></td>
<td>2 tons.</td>
<td>1 ton.</td>
</tr>
</tbody>
</table>

**Results in 1897.**—Comparatively few beetles came from neighboring fields and hence the results were more satisfactory than in 1896. As shown in the diagram the yield of the half acre which was sprayed three times was twice that of the half acre sprayed but once.

The results of spraying alone as a means of combating the beetles compared with depending entirely upon the machines for catching the insects may be shown by comparing Plat I to a near-by field upon which the machines alone were used. The conditions were practically the same in both cases and the yield was about the same but there was a decided difference in the cost of treatment. In the field referred to a machine was kept running a part of every day for nearly three weeks, which is not exceptional, at a cost of $4.05 per acre for labor while the cost of spraying, with a power sprayer covering six rows, was but $2.58 per acre for labor and materials for the three applications. Thus the expense of spraying was but little compared to the yield and much less than the cost of running the machines long enough to produce the same results.7

**Should spraying alone be depended upon in combating this insect?**

Although the results in the above experiments are very gratifying in favor of spraying, in many seasons it will be found imprac-

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7In the field referred to the machines were used but once a day throughout the entire three weeks. Usually it is necessary to go over the fields twice a day for a week or ten days, thus increasing the expense.
tical to depend upon this means alone in combating this insect. Usually the willows are too large before time for the third treatment to spray to the best advantage and hence the machine should be brought into use for a short time if necessary. On newly planted fields, however, spraying will be found of special advantage in keeping off the insects while the willows are getting a start and before they are high enough for the machines.

**IMPORTANT OF A UNITED EFFORT OF THE WILLOW GROWERS.**

Insects which migrate as readily as the cottonwood leaf-beetle will quickly spread over a community where their food plant is extensively grown. The adults of this species fly readily and probably for quite long distances. In the fields about Syracuse, they literally swarm upon the willows, coming from all directions, especially from neglected fields, which of late years are becoming common in this community. A neglected field of willows means that the beetles will breed there unmolested and as food becomes short or as migratory instincts dictate, will seek other fields in the vicinity. Several illustrations of this kind came to the writer's notice at Liverpool. Willow growers whose fields were in the vicinity of neglected fields suffered greater loss from injury to the willows, or were put to greater expense in combating the insect than were those whose neighbors united with them in an effort to check the pest.
RECOMMENDATIONS.

Begin spraying early in the season. Make the first application before the beetles become numerous and follow it by one or two more a week or ten days apart.

Use green arsenite or other equally good arsenical, one pound to 100 gallons of water, with the addition of enough freshly slaked lime to make the mixture slightly milky in appearance. One pound of whale oil soap to about 20 gallons of the mixture may be added with good results. It will do no harm to use the soap stronger.

Spray newly planted fields with the poison until the willows are large enough for the machines.

After the willows are too high to spray thoroughly by ordinary means, use the machines for catching the insects if necessary.

Urge the importance of a united effort on the part of all interested in willow growing.

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Aldrich, J. M. Insect Life, 4: 67. Abundant in South Dakota, seems to prefer New Russian poplars; can be controlled by arsenicals.


Ibid, p. 5. 7. Mentioned.

N. Y. State Entomologist Rept. 1895: 181-189 General account, notes on insect's destructiveness; descriptions of larva and imago; note on the willow-basket-making industry in New York. Illustrated.


II. GREEN ARSENITE.

Under this name the Adler Color and Chemical Works have placed upon the market an arsenical which may be used in place of ordinary Paris green. As stated in the Fifteenth Annual Report of this Station, pages 536–539, samples were sent to the Station in 1896 for experiment. During 1897 two other samples were sent for the same purpose. In addition to the experiments the poison has been extensively used in place of Paris green in the station orchard during the past two seasons with excellent results.

NATURE AND COMPOSITION OF GREEN ARSENITE.

In general appearance green arsenite resembles ordinary Paris green. It differs chemically from this poison in being a simple arsenite instead of an aceto-arsenite of copper, and physically in being an impalpable powder while Paris green is crystalline.

Green arsenite is said to be similar to if not identical with Scheele's green, but according to samples sent by the manufacturers to the Station the percentage of arsenious oxide may vary from 41.04 to 62 per cent, while Scheele's green contains, theoretically 52.94 per cent.

WHEN FIRST USED USED AS AN INSECTICIDE.

Mr. C. L. Marlatt of the United States Department of Agriculture, Division of Entomology, was probably the first to use green arsenite in place of Paris green. Mr. Marlatt\(^8\) states that copper arsenite (green arsenite) was especially made for him in 1894 by a prominent manufacturer of Paris green and that it is in reality Paris green, without the addition of acetic acid which is added to produce a more or less coarsely crystalline product.

In a publication of the Department of Agriculture, Mr. Marlatt\(^9\) gives the results of experiments with this insecticide. He

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\(^8\)Insect Life, 7: 408–411.

found that the action of the simple arsenite of copper on the foliage of various plants used in the experiments was practically the same as Paris green. Again in a subsequent bulletin Mr. Marlatt gives results of experiments with this and other arsenicals.

ADVANTAGES OF GREEN ARSENITE OVER PARIS GREEN.

In addition to the comparatively low cost of manufacture the principal advantage of green arsenite over Paris green is that, as it is so much more finely divided, it remains in suspension in water much longer. From experiments in the laboratory the writer found that the ordinary crystalline Paris green, when mixed with water at the rate of 1 lb. to 150 gallons, would sink to the bottom of the jar in about five minutes, leaving the water clear, while the green arsenite remained in suspension for over two hours.

It is because the green arsenite stays suspended in water so much longer than Paris green, that it is more valuable as an insecticide. Without doubt much of the failure to get good results from Paris green is because of the difficulty of keeping it evenly distributed through the tank. Unless the mixture is almost constantly agitated, the Paris green sinks to the bottom and is quickly drawn out by the pump, so that before the tank is half empty, most of the poison is gone and the remainder of the water contains so little Paris green as to be hardly worth applying.

HOW TO USE GREEN ARSENITE.

Green arsenite should be used the same as Paris green. For ordinary purposes use one pound to from 100 to 150 gallons of water with the addition of enough freshly slaked lime to make the mixture slightly "milky" in appearance. Lime should always be added, for, in addition to other uses, it prevents injury to the foliage. It may be used with Bordeaux mixture in the same manner as Paris green.

PRICE PER POUND AND WHERE OBTAINED

Green arsenite can be obtained from the Adler Color and Chem-

ical Works, New York, and probably from other leading dealers in similar products for 15 cents per pound.

EXPERIMENTS WITH GREEN ARSENITE.

No strictly comparative experiments with this insecticide have been made here at the Station. Comparative tests$^{12}$ by C. L. Marlatt however, indicate that green arsenite and Paris green are equally effective as insecticides.

Experiments with green arsenite made by the writer are recorded on pages 600–601 of Bulletin 136 of this Station and on previous pages of this Bulletin. In the former instance the insecticide was successfully used against a flea beetle, *Systena hudsonias* Forst. attacking young apple grafts, and in the latter with equal success against the cottonwood leaf-beetle, *Lina scripta* Fab.

In the spring of 1896 and again in 1897, the writer used green arsenite against the spring canker worm in an orchard near the Station. Fourteen large bearing apple trees were used in the experiments. Both seasons the trees were sprayed three times, the first being about the middle of May and the remaining two from a week to ten days apart. In 1896 the remainder of the infested orchard was sprayed with ordinary Paris green, and in 1897 the green arsenite alone was used. In 1896 the trees sprayed with green arsenite were more uniformly free from canker worms than those sprayed with Paris green, while in 1897 the sprayed trees were practically free from canker worms after the second application, which was made May 22, while the unsprayed trees were nearly stripped of their foliage.

In addition to the above experiments the writer has used green arsenite upon young pear trees against the fruit worm and upon potatoes against the Colorado potato beetle. In both instances the poison was used at the rate of 1 pound to 150 gallons of water with the addition of enough freshly slaked lime to make the mixture slightly milky in appearance, and gave every indication of being equally as efficient as Paris green.

EXPLANATION OF PLATES.

**Plate I.**—Young willow whips injured by the cottonwood leaf-beetle.

**Plate II.**—Uninjured willow whip and one which was injured at an early in season causing it to branch.

**Plate III.**—1. Willow leaves showing eggs attached and injury by young larvae. 2. Larva natural size and enlarged. 3. Pupae attached to willow leaf, natural size. 4. Pupa enlarged. 5. Beetles natural size and enlarged.

**Plate IV.**—Machine for catching the beetles.

**Plate V.**—Machine in position ready for use.

**Plate VI.**—Hand power machine.