

SB

608

Q7H6

copy 2

UNIVERSITY OF CAL,
College of Agri'e
SUPPLEMENT, No 1.
To the Report
OF THE
Bd. of Regents

DI

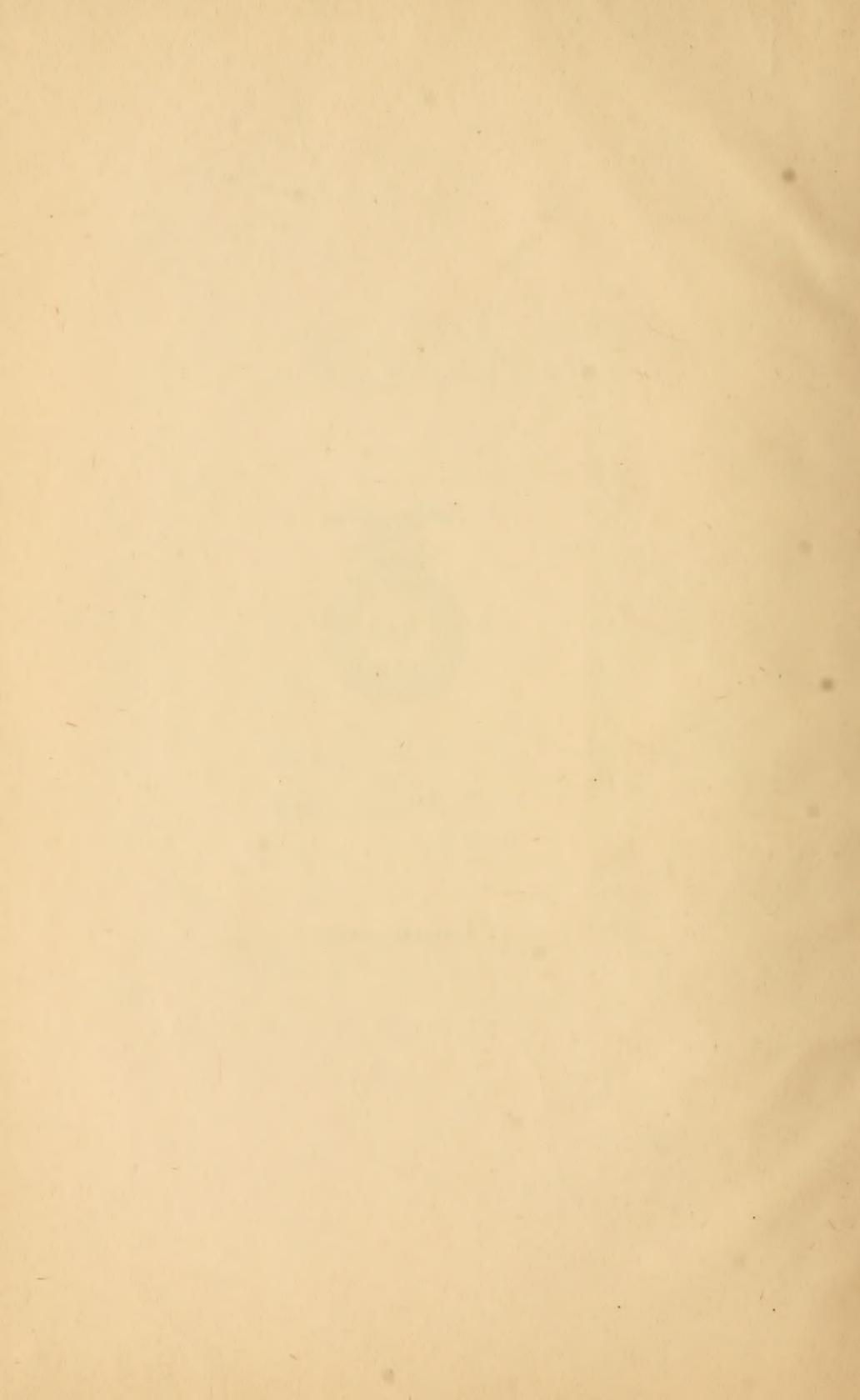


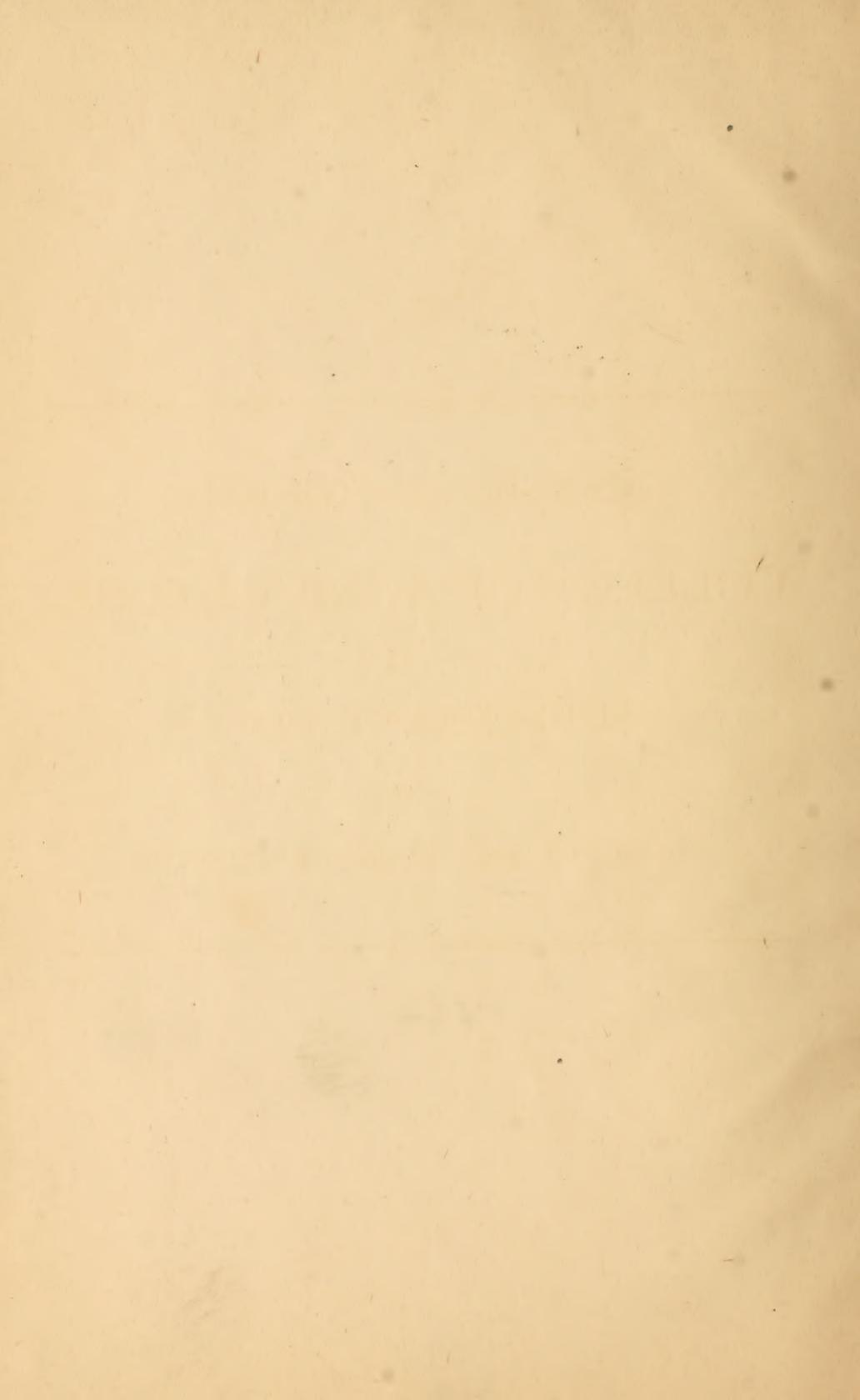
Class SB 608

Book G7 H6
copy 2

Bc

PRESENTED BY





5395

7772

SB 608
GT 7 H6
copy 2

JUL 26 1904
D. of D.

.....

.....

THE PHYLLOXERA OR GRAPEVINE LOUSE, AND THE REMEDIES FOR ITS RAVAGES.*

BY EUGENE W. HILGARD,

Professor of Agriculture in the University of California.

The name Phylloxera, † meaning leaf witherer, was originally given to a kind of plant louse which infests the European oak. We are now acquainted with sixteen species, of which only one, the *Ph. vastatrix*, of Planchon, affects the interests of man. The study of the others, however, has materially assisted in ascertaining the habits and life history of that one important species, which forms the subject of the present paper.

It was first observed in America in eighteen hundred and fifty-six, by Asa Fitch, of New York, on the leaves of native vines, and by him named *Pemphigus vitifoliæ*. Other names were subsequently applied by other observers to its various forms, until, about the year eighteen hundred and seventy, their identity was demonstrated by Lichtenstein, Riley, and others.

All the earlier names and descriptions refer to the leaf-inhabiting and winged form of the insect.

The Root Rot or "*Pourridie*" of the vines, first mentioned as existing in France about the years eighteen hundred and sixty-five and six, was shown to be due to wingless lice, in eighteen hundred and sixty-eight, by Planchon. But the identity of these root lice with those inhabiting the leaf-galls of certain native American vines, was for some time not even suspected. After attention had been called to their close resemblance, and to the fact that the Leaf Gall Louse descended to the root in winter, attempts were made, both in this country and in Europe, to transplant root lice to the leaves; many of which were unsuccessful, in consequence of the failure of observers to select suitable varieties of vines. Finally, in eighteen hundred and seventy and eighteen hundred and seventy-one, Riley conclusively proved the identity of the two types, by effecting the change of habit either way, on vines properly selected. He also showed that the all but universal failure of the European vines, as well as that of certain delicate native varieties in the Mississippi Valley, observed long since, was due to the attacks of the Root Louse.

* Revision of "A Lecture on the Phylloxera or Grapevine Louse, delivered before the State Vinicultural Association, at San Francisco, November twenty-third, eighteen hundred and seventy-five," and forming Bulletin Number Twenty-three of the University of California, issued in January, eighteen hundred and seventy-six.

† Pronounced as if spelled *fillo-xee-ra*; emphasis on *xee*.

When, six years ago, I first examined the diseased vines in the Sonoma Valley, I was forcibly struck with the fact that I had handled vines precisely so circumstanced, thirty years ago, when my father, among the first, attempted the culture of Rhenish grapes in southern Illinois.

From eighteen hundred and seventy, up to this time, the Phylloxera has spread in France with frightful rapidity, destroying wholly or partially thousands upon thousands of acres in the vine-growing districts. In eighteen hundred and seventy-one, the French Academy appointed a standing Phylloxera committee, whose reports and discussions often occupy a large portion of the weekly session. A prize of, first, thirty thousand, then sixty thousand, then three hundred thousand francs, has been offered for the discovery of an effectual and practicable remedy. But although hundreds have been brought forward, the prize has not yet been awarded. Meanwhile the existence and ravages of the insect have become obvious in Germany, Austria, Italy, Portugal, and Spain. Universal alarm has been created in these countries, and the literature of the subject has become exceedingly voluminous.

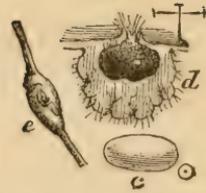
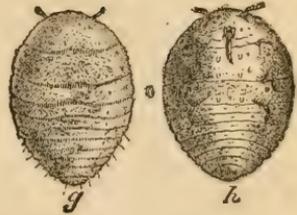
In eighteen hundred and seventy-three, the French Government sent Planchon, a prominent scientist, to observe the Phylloxera in its native haunts in the United States; it being now considered certain that the insect is at home on native American vines—which it does not materially damage in their wild condition—and has been imported into other countries with them. Planchon's observations and reports have fully confirmed, in all essential points, those previously made by Riley and other American observers. Riley's observations, published chiefly in the reports made by him as State Entomologist of Missouri, are by far the most complete and reliable made in this country; and to his publications I am largely indebted for the material, and for the illustrations of the present paper.

DESCRIPTION OF THE PHYLLOXERA.

In most respects the Phylloxera resembles the common plant lice (*Aphis*), the main difference being that its wings lie flat, and overlap on the back, instead of being erected roof-fashion; and that the three-jointed antennæ have the terminal joint much the longest. All are quite small, the perfect winged form of the Vine Louse being about one twentieth of an inch in length. Its peculiar feature is the great variety of forms which it is capable of assuming under different circumstances. Among them we distinguish two chief types, viz: the leaf-inhabiting one or Gall Louse, and the root-inhabiting or Root Louse.

THE GALL LOUSE.

The Gall Louse habitually infests the leaves of certain native grapes in the Eastern States, especially those of the Riverside and Frost Grape (*Vitis riparia* and *cordifolia*). It covers the surface of the leaf with numerous fleshy swellings, of irregular shape, and often partially of a reddish tint. In them we find a wingless female louse, one twenty-fifth of an inch long.

Fig. 1.*Fig. 2.**Fig. 3.*

THE GALL LOUSE. Fig. 1—Vine leaf covered with galls. Fig. 2—Section of a gall and egg. Fig. 3—Mother gall louse.

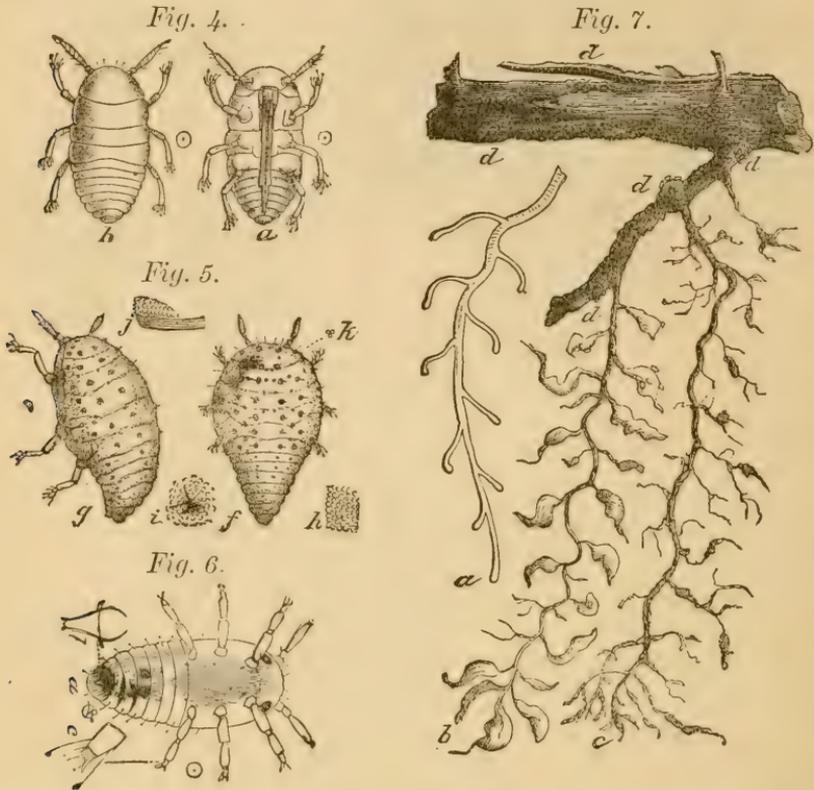
When the gall is filled with from two hundred to five hundred eggs, the mother louse dies. The eggs hatch in from six to eight days into active little larvæ, of oval form, which soon leave the gall, go to the upper surface of downy young leaves, and insert their suckers. The latter consist of three fine threads, surrounded by a blunt and hairy sheath. The leaves soon begin to swell below, while a reddish down surrounds the louse above, gradually closing in. On suitable vines, the gall forms in a few days, and the grown louse begins to deposit eggs, fills the gall, and dies. The young lice not only attack the leaves, but also cover the tender shoots, and even the tendrils, with swellings.

It has been calculated, that at the rate of five hundred eggs in each gall, the progeny of five or six generations would, if placed end to end, reach thirty times around the earth; but under ordinary circumstances so few survive that the damage done is comparatively trifling, and readily prevented by early attention.

Towards the end of September the galls are mostly empty, the lice having gone to the roots to hibernate.

THE ROOT LOUSE.

The life history of the root-inhabiting type of Phylloxera is much more complex than that of the Gall Louse.



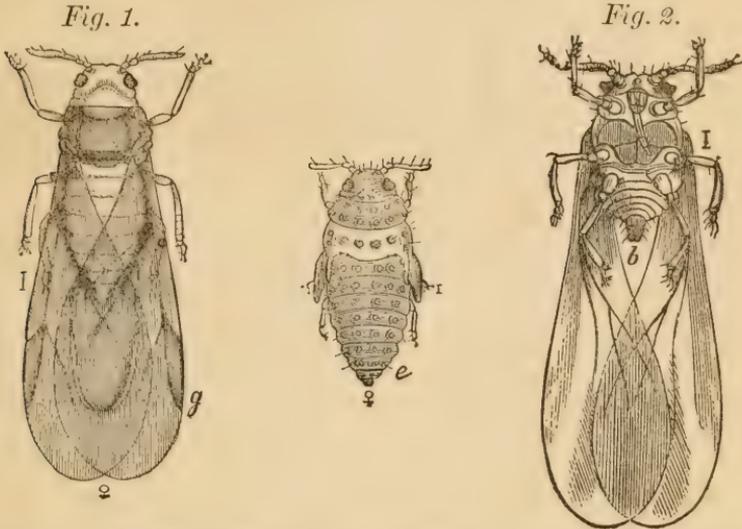
THE ROOT LOUSE. Fig. 4—Young larvæ. Fig. 5—Adult (egg-laying) larvæ. Fig. 6—Male insect. Fig. 7—Vine root, with colonies of eggs and insects on main root; sound rootlet; rootlets with swellings; dead rootlets; black.

The newly hatched larvæ of either are alike. Those of the Root Louse soon acquire tubercles over their surface; these, however, are irregular, only skin deep, and sometimes absent. As the development progresses, two forms begin to differentiate themselves. One is of a somewhat pointed egg or pear-shape, and resembles the wingless Gall Louse; the other is of an oval form.

The former is the mother Root Louse; it remains on the root through life, sucking the mother Root Louse; it remains on the root through life, sucking its juices, locating itself and its colonies by preference in crevices, creases, etc. At maturity, without sexual impregnation, each lays upwards of two hundred and fifty eggs, which on hatching again rapidly go through the same round of life.

THE WINGED FORM.

The oval form of the Root Louse larva is destined to become winged.



THE WINGED PHYLLOXERA. Fig. 1.—Fertile variety, long-bodied; e, young insect with wing-pads. Fig. 2.—Sterile, short-bodied variety.

From the time it has achieved one third of its growth, the wing pads, or rudimentary wings, are visible. The individuals are more active than those of the wingless form, and are often seen crawling about; finally, in July* and August they shed their last skin, and take wing. The winged form has neither tubercles nor granules on its back. All are females; a supposed male form, with shorter abdomen, proves to be merely a barren female. The perfect ones deposit from two to eight eggs where they alight, and then perish.

The eggs are of two kinds: the larger, about two hundredths of an inch in length, are of the female sex; the others, about two fifths smaller, hatch into males; the time required being about a fortnight.

The sexual individuals thus produced are again wingless; more than that, they are destitute of sucker, mouth, or alimentary canal, being evidently destined exclusively for the reproduction of their species. They are quite active and couple freely.

These sexual females lay but one single egg apiece. This solitary egg, which is destined to hibernate, and hatch in Spring, produces again the ordinary mother Root Louse, which lays several hundred eggs, and is capable of repeating itself without sexual impregnation, for five or six generations.

So far it would seem as though the production of the winged form at intervals were necessary for the renewal of the vigor of the species; and that, if its appearance could be prevented, or itself or its brood be destroyed, the Phylloxera might be almost exterminated.

* About that time there is usually a marked increase in the number of the insects, known as the "July invasion" in France.

Unfortunately, other observations have shown that nature has provided against the possibility of thus getting rid of the pest. Under circumstances not fully understood, the ordinary form of Mother Louse also at times performs the office of the sexual females, and lays the large solitary egg which is necessary for the rejuvenation of the insect.

Such multiplicity of forms, of provisions for the perpetuity of the species, combined with such elasticity of habit, is not thus far known to exist in any other insect; albeit similar transformations have been observed in the species that inhabits the oak.

IDENTITY OF THE GALL AND ROOT LOUSE.

The identity, and convertibility into each other, of the two principal forms of Phylloxera, were long doubted. This was especially the case in Europe, where the conditions of the change of habit did not then exist. Many attempts to transplant the Root Louse to the leaves failed; which is not surprising, when we consider that, as Riley showed, the insect does not form galls readily even on the Clinton vine, after having lived on the roots of other varieties for several generations. The leaves of the Clinton, and of its wild ancestor, the Riverside Grape, seem to be best of all adapted to the taste of the Gall Louse. In the South I have seen whole arbors of the Frost Grape (*Vitis cordifolia*) thickly covered with galls, so as to prevent its bearing altogether. Its roots, however, are scarcely at all infested during the growing season, but only serve as a retreat for hibernation or wintering.

On grape varieties whose leaves are not to its taste, the Phylloxera either forms no galls at all, or abandons them after making a trial, leaving "abortive" galls. In some cases it has been found living under the bark, above ground. Koehler (at Kloster-Neuburg), and Balbiani, succeeded in making the Root Louse live on the under surface of the leaves, in the third generation. The fact that the habits and mode of development of the insect depend very largely upon the nature of the vine, so that it will refuse to live on the *leaves* of some varieties, and decline the *roots* of others, is the key to the whole mystery of its changes of habit, whose importance was first fully shown by Riley. The failure to take this important consideration into account, explains the wide divergence in the results and conclusions of different observers and experimenters. More than this, it furnishes the most important cue to the prevention of the ravages of the insect in the vineyards of the future.

On the European vine (*V. vinifera*, which includes the Mission grape of California), leaf-galls have scarcely been known to be formed; the attacks of the insect are altogether directed against the roots. The exact reverse is true of the native Riverside Grape of the Eastern States, from which the Clinton and related varieties are derived. Of the other American varieties, those descended from the Fox Grape (*Vitis labrusca*) of the Atlantic States, such as the Catawba and Isabella, are most liable to the attacks of the Root Louse; while those derived from the Summer Grape (*V. Aestivalis*), such as Norton's Virginia Seedling, as well as the hybrids, differ greatly in these respects, each requiring special experiment in different localities and climates, to determine their nature and powers of resistance.

The Gall Louse is found occasionally on most of the grape varieties

cultivated in the Eastern States. When placed on uncongenial foliage it descends to the roots. It was from the progeny of such lice that Riley obtained galls on the Clinton vine, which, with the Taylor, is most liable to its attacks. As, however, it refuses to live on the leaves of the European vine, it is scarcely known in France, save on imported American varieties.

THE SPREAD OF THE PHYLLOXERA IN EUROPE.

Since the Gall Louse never acquires wings, it can spread but slowly, by crawling. The same is true of the Root Louse, so long as it does not assume the winged form. It then migrates through crevices in the soil, or along the roots; or even over the surface of the ground, provided that the latter be not too sandy. Being unable to travel over or through sand, its development and progress is so checked in sandy regions as to render it almost powerless for harm. This circumstance explains the fact that such regions have enjoyed almost complete immunity when adjoining ones were overrun with the plague. It is doubtless from this cause that the European grape has been successfully cultivated in the coast region of the Gulf of Mexico, while it has totally failed on the more generally clayey soils of the Western States.

But the matter assumes quite a different aspect when the winged form makes its appearance. It is not known what percentage of the Root Louse progeny assumes this form under ordinary conditions; but it is certain that, at times, the winged insects appear in countless numbers in July and August. They do not seem to possess great powers of flight, but are so light and the wings so large in proportion to the weight, that the lightest breeze carries them along with ease. As to the objective point of their voyage, they do not seem to exert much selection, and the question as to the particular locality where the eggs are ordinarily intended to be deposited, has been much discussed. It is certain that, after alighting, they seek to lay their eggs in some furzy place, such as buds, or woolly leaves, or their axils, etc., since the eggs appear to be deposited indifferently in any such spot, whether on a vine or any other plant or tree. It is thus obvious why the spread of the insect has been so much more rapid in France—where vineyards extend uninterruptedly over extensive tracts—than in America, where they are mostly separated by intervening screens of woodland, on which large numbers must alight in their random flight, and, of course, perish for want of suitable food. This circumstance conveys an important hint in regard to the prevention of the spread of the insect. But it is also obvious, from the facts just quoted, that the eggs may be conveyed from one place to the other, both in cuttings and in the material used for packing, as well as in numerous other ways. It is true that, under ordinary circumstances, the eggs hatch within a fortnight; but should cold weather supervene, they may remain dormant, as do the eggs deposited on the roots by the last generation of mother lice, which, together with the larvæ, constitute the hibernating reserve. In such a case, of course, the insect would be ready to revive and flourish wherever the cutting should happen to be planted; and it is doubtless in this manner that it has found its way into many a vineyard, and even across the sea.

The larvæ wintering on the roots are of a dingy color, and not easily seen; they are attached to the roots by strong suckers. Early in spring they revive, the eggs hatch, and the uninterrupted round of generation is resumed.

INJURY DONE TO VINES.

The injury ordinarily done by the Gall Louse is comparatively insignificant, or easily rendered so by a little early attention—clipping off and destroying the infested leaves. It is only when neglected until it has developed for several generations, that it passes beyond control, and materially injures the crop on such varieties as are favorable to its development.

It is quite otherwise with the Root Louse, whose presence is usually unsuspected until it has seriously injured one crop at least, and which, in any case, it is most difficult to reach.

The first effect produced by the attack of the louse is a swelling of the tender white rootlets, which it prefers to the older and harder portions. In the center of these rounded, semi-transparent swellings, the puncture may be seen as a minute black dot, from which the rot commences after the insect deserts it for a new position. It has been thought that this prompt decay is induced by a secretion that the animal injects into the wound; but it is more probably due to the inability of the deformed rootlets to undergo the normal process of transformation into dark, woody root fibers.

As the invading army moves on, root after root is left behind to decay. During the first year, the vine usually shows but little appearance of disease, save that the fruit is slow to ripen, or matures but imperfectly. The lice being chiefly on the outlying rootlets, simply arrest the normal increase without harming the vitality of the vine.

During the second year, the enemy rapidly approaches the center, destroying all the finer rootlets. The vine appears sickly, with stunted, yellowish leaves, and fails to mature fruit.

Some of the weaker vines succumb, so as to fail to put out leaves the third year. The stronger ones hold out through the season by the aid of two or three remaining roots, from the fact that the Root Louse, being somewhat dainty in its feeding, deserts a dying vine before it is completely exhausted, for "fresh fields and pastures new." This fact, the significance of which has been confirmed by direct experiment in France, shows that a weak or diseased condition of the vine is not, as has been supposed, a determining cause of the attack; since the Louse prefers vigorous vines whenever it has the choice. Of course, however, a weak and old vine ordinarily succumbs sooner than a strong and young one; and hence in the case of vines not constitutionally very well adapted to the nature of the Root Louse, the mere strengthening of its vitality by means of proper manures is sometimes sufficient to keep them in profitable bearing.

The fundamental importance of a judicious selection of vines with regard to their resistance to the Phylloxera, is thus obvious.

Unfortunately, up to the present time, nearly all the grape varieties planted in California belong to one of the most sensitive species—the "Old World" (*Vitis vinifera*). It is true that some of these are somewhat hardier than others; but none has so far shown any such degree of resistance to the Phylloxera, as to do more than to prolong the

life of the vine for a few years. The claim advanced by some that the Mission grape is resistant, is based upon a confounding of the Mission with the wild native vine of California, which indeed appears to be as indifferent to the attack of the insect as any of the wild grapes of the East. Other things being equal, the Mission vine is found to succumb about as readily as any other.

The sweeping destruction that has followed the invasion of the French vineyards by the Phylloxera, is a matter of notoriety, and the sorrowful record need not be detailed here. When its presence was first recognized in the Sonoma Valley, it was naturally supposed that in a climate apparently so favorable to the development of the insect, its progress would be at least equally as rapid as in Europe. But from some cause not yet understood, its advance, though steady and inexorable, has been comparatively slow. Instead of twenty or thirty miles annually, its outposts have advanced only two or three, and sometimes much less, in each year. Again, while the ultimate fate of vineyards has been the same as everywhere else, and in the Sonoma Valley especially, hundreds of acres, once covered with vines, have been converted into wheat fields: yet on the whole it appears that the work of destruction has required a longer time; that the vines have continued in profitable bearing two and even three years after the first attack, when growing on strong soil, and well cultivated.

The last mentioned difference may be accounted for by the comparative youth of the vines, and the freshness of the soils. But the slow advance made by the insect requires some explanation, not yet fully found in the facts thus far observed. I was indeed led to hope that the winged form, through which chiefly the rapid diffusion of the pest is accomplished, might not be produced at all in California. Observations made during the present season have shown this hope to be fallacious, at least in so far that a considerable number of winged individuals was produced from infested roots brought from Sonoma, inclosed in jars filled with earth, under the care of Dr. J. S. Hyde, of Santa Rosa. Of these, a large proportion, especially of the earlier broods, was found to be of the short-bodied, and presumably infertile variety, figured above (p. 7).

Observations made somewhat later (in September), by residents of the Sonoma Valley, have failed to reveal the presence of the winged form in the vineyards, and it still remains true that it has not as yet been seen abroad in California. And while there can be little doubt that closer observation, earlier in the next season, will reveal its presence in the open air, yet the presumption remains, that the production of the winged form, and the spread of the plague through its agency, is in some way limited in the Californian climate, whether simply as regards its numbers, or through the predominant production of the sterile variety, during the season when the regular winds would be most likely to carry the minute flies to great distances. Were the winged form produced, at any season, in such numbers as have appeared elsewhere, their presence could hardly have remained unnoticed by the many persons who have been looking for them during the past two years.

Be that as it may, the unquestionable fact remains, that since the insect spreads much more slowly in California than in France, it must be to that extent easier to check its progress; and that we may

succeed in doing so through means that have proved too expensive elsewhere. What these means are, I now proceed to discuss.

COMBATING THE PHYLLOXERA.

The problem to be solved in combating the Phylloxera is a difficult one, not because of any tenacity of life in the insect itself, but simply on account of the difficulty of *devising any means that will reach every one of the matted rootlets of a vineyard, over its entire surface, and to a depth of from three to four feet*; with the additional conditions that *the remedy must be cheap, not only as regards the material, but also the work of application, and must not injure the vine materially.*

It is perfectly easy to devise thousands of compounds that will kill the insect, which is soft, jelly-like, and a few days after death is only represented by a thin, empty membrane hanging to its sucker. It is not nearly so easy to kill the eggs, which is of course of equal importance. Almost any substance or operation energetic enough to kill the eggs, will hurt the white rootlets more or less; and it is on these that the living insect is usually found in the greatest abundance, while the eggs are by preference deposited on older roots, whose bark and crevices afford them more protection. *Both, and all of them*, must therefore be reached if the insect is to be extirpated. The depth to which the roots reach varies with the soil and location, but is rarely less than three feet. In rows eight feet apart, the white roots usually interlock between the rows, so that the insect can migrate from one row to another without going above ground.

Next to air, the cheapest medium for saturating the whole soil of a field to the minimum depth of three feet, is WATER; and the most obvious method for the destruction of the Phylloxera is, therefore,

I.—SUBMERSION.

I have already stated that the prize of the French Government for "an efficacious and practical remedy" for the ravages of the Phylloxera has not yet been awarded. Several of the remedies suggested fulfill one of these two indispensable conditions, and for a not inconsiderable class of localities, submersion fulfills both; but it must be applied to the infested vines for a sufficient length of time; *i. e.*, for not less than thirty days in autumn, or even forty in winter. Wherever this can be done at a reasonable cost, the Phylloxera may be defied. The remedy, of course, is available to a limited extent only; yet it has been applied, in France, in localities where steam irrigating machines had to be constructed for the purpose—because of the high commercial value of the product of particular vineyards.

The great length of submersion necessary to destroy the Root Louse and its progeny (as ascertained by experiment), renders it indispensable to perform the operation while vegetation is in abeyance. It is found that submersion during the growing season, for a longer time than three days, materially injures the vine, while it does not sensibly interfere with the well-being of the insect. At the same time, whenever the latter has assumed, or even approached, the wintering condition, it is prepared for the conflict with the elements, and much more difficult to destroy. The sooner after the cessation of vegetation, therefore, the operation of submersion can be performed, the shorter will be the time required to exterminate the enemy. In

pervious soils, also, the effect will be produced in less time; showing that the reason why it takes so long to kill the louse is not so much its ability to resist drowning, as the circumstance that it takes a much longer time than is usually supposed, to fill the soil with water.

In general, nevertheless, wet is decidedly injurious to the Phylloxera. It is less troublesome in wet soils, and wet seasons sometimes check its progress materially. In connection with this point, it is important to remark, that experiment has shown light soils with a wet subsoil not to be as unfavorable to the vine as has often been supposed. The fact that several of our native vines are originally found on such soils only, naturally points to this conclusion, as well as to the grape varieties most likely to succeed in low ground. That such localities are most readily submerged, in case of need, is an additional weighty reason for locating vineyards on them, provided, of course, that the production of high quality wines is not intended.

It would thus seem that the climate of California is exceptionally favorable to the rapid increase of the Phylloxera. Even our wettest winters cannot drown out the hardy eggs and hibernating larvæ. On the other hand, our long dry season, which never fails, offers the insect a chance for uninterrupted development and indefinite multiplication, such as is scarcely to be found elsewhere. Add to this the circumstance that our prevalently heavy soils afford it additional advantages, by the facility with which it can travel from vine to vine and from vineyard to vineyard, through the crevices of the sun-cracked surface, and we have a concatenation of advantages on the side of the insect which warns us that, unless vigorous preventive measures are taken, the vineyards of the State must all ultimately succumb to its attacks.

II.—SANDING.

It has been proposed to employ the inability of the insect to travel or flourish in sandy soils, as a means for its destruction. But, plausible as this seems at first sight, it lacks the essential feature of practicability on any but a very limited scale. To merely surround the stock with sand, may close to the insect this very convenient outlet; but it will not in the least interfere with its crawling to the surface through crevices elsewhere, nor stop its underground communication, through sun-cracks, and along the roots which interlock between the rows. Unless, therefore, the application of sand is carried to the extent of actually converting a heavy soil into a sandy one, but little good can be expected of it. That the expense of this operation would, in the vast majority of cases, be an effectual bar to its application, scarcely requires discussion; still it should be kept in view, since at times a mere diversion of the drainage may be sufficient to effect a beneficial change in the course of time. At all events, the principle may find an important application in circumscribing the spread of the wingless form, by means of ditches filled with sand.

It has been proposed in the volcanic districts of southern France, to replace the mere arid sand by the volcanic sand or ashes, which can be readily obtained in many cases, and would, by its gradual decomposition, supply valuable soil ingredients, or plant food.

The same objection that lies against the efficacy of sand placed around the stock of the vine only, applies equally to other impediments put in the same place: such as plaster cast around and smeared with tar or other sticky substances; or tarred sawdust similarly

applied. The Root Louse, wingless or winged, may choose this as an easy route when it is open; but with its usual fertility in resources, it finds other outlets without much trouble, when that one is closed.

III.—INSECTICIDES.

The fact that any measures intended for the repression or destruction of the Phylloxera must, in order to be effective, extend not only over the entire surface, but also into the depths of the soil as far as the rootlets of the vine reach, renders the use of insecticides, or poisons of any kind, both difficult and expensive of application. An immense number of these have been proposed, but a few only have proven of any practical value; partly because of the expense attending their use, partly from the liability of the most effective ones among them to injure the vine as well as the Phylloxera, unless used with great caution.

A list of all the remedies proposed would be a long one, and at the present time of interest only in so far, as it would show to inventors what has been already tried and found wanting. The essential conditions above enunciated, that any effective remedy against the Phylloxera must admit of being applied over the entire surface, and to a depth practically equal to nearly three feet, within reasonable limits of expenditure, at once throws out of consideration all but the cheapest materials, or those capable of being readily diffused throughout this great mass of soil without losing their efficacy. The many mysterious compounds, powders, etc., proclaimed from time to time as "Sure to kill the Phylloxera and not injure the vine," are but a few of many thousands of such that could be devised for the purpose, but no more practically useful than the well-known flea remedy, which was to be applied to the insect held firmly between the thumb and forefinger, compelling it to open its jaws for the introduction of the poison.

Insecticide Solutions.

Water naturally suggests itself as the cheapest vehicle through which a soluble insecticide can be introduced into every particle of the soil-mass to be treated. To a certain extent this principle can be usefully acted upon, and yet it is practically much less available than would appear probable at first blush. It has already been stated that when the ground can be kept flooded for a sufficient length of time, the Phylloxera can be, if not extirpated, at least kept in check, so as to be harmless. In such cases no insecticide, properly so called, is needed. When, on the other hand, a quantity of water sufficient to saturate so large a mass of soil has to be put on the ground by artificial means, and at the same time charged with a more or less expensive insecticide, the cost readily becomes such as to exceed the value of the vineyard. This is largely due to the fact that the soil is a powerful absorbent of almost all substances soluble in water, thereby rendering them inactive toward animal life, for the time being. The same disinfecting property of soil that enables it to purify the foulest water filtered through it, without itself becoming offensive, also serves to render ineffectual a large proportion of any poison that may be introduced in watery solution. It is only after the soil has become saturated with it to a certain (very variable) extent, that a remaining portion can become effective. Hence, the amount needed of any

insecticide, when used in the soil, is very much greater than that which would be required if water were to be applied to the insect directly. A solution of carbolic acid, or a tea of the "Persian insect powder," that would be instant death to an insect sprinkled with it, becomes inodorous and harmless when filtered through a few inches of soil; and the same is more or less true of all kinds of poisons.

Again, it is quite useless to propose to "bare the roots of the vine" for any insecticide application on the large scale. In a bearing vineyard the roots and rootlets form one matted mass all through the soil over the entire field, and it is at the remote ends that the insect forms its largest and most flourishing colonies. To bare all these is practically impossible, and would in any case involve an amount of labor incompatible with the profitable maintenance of the vineyard; especially if, in addition, the insecticide is to be carefully applied to all, and soaked in with water, as is mostly suggested by the proposers of such impracticable schemes.

Gases.

The use of poisonous *gases* to be generated from substances introduced into the soil in small quantities was early suggested, and was followed up by the use of compounds capable of producing a slow generation, especially of sulphuretted hydrogen; a gas readily produced from cheap materials, and instantly fatal to insects, even in minute quantities. Its effects on the latter proved to be all that could be desired; but it was found to be almost equally fatal to the vines themselves, and was, therefore, soon abandoned. The same was found to hold true in regard to phosphoretted hydrogen and several other gases, whose cost alone would exclude them from use on the large scale.

Bisulphide of Carbon.

In the industrious search for a gas or vapor that would kill the insects without materially affecting the vine, the *bisulphide of carbon* was early experimented upon. This substance is cheaply made by burning charcoal in sulphur vapor, in red hot iron or earthenware vessels. The vapor formed is very heavy and volatile, and requires very effectual arrangements for condensation. When *pure* it forms a colorless liquid, about one fourth heavier than water, of an aromatic and somewhat peppery odor, which is not disagreeable, and produces somewhat the effects of chloroform on the human subject, but acts as quick as poison when inhaled by small animals. Ordinarily, however, it is contaminated with other sulphur compounds, which give it the offensive odor of rotten eggs and onions; and in this condition it is poisonous when inhaled, not only to animals, but also to man. The very offensiveness of its vapor, however, is an excellent safeguard against accidents from poisoning. It is highly inflammable, and its vapor, when mixed with air, explodes, like that of petroleum spirit or alcohol. Since it boils but a little above the temperature of the hand, it evaporates very rapidly when poured on it, producing a feeling of intense cold; when poured on damp earth, the latter soon freezes and becomes covered with hoar frost. The vapor so formed is three times heavier than air, and flows down visibly, like water, from the mouth of an open vessel containing the liquid. It is not sensibly absorbed by water, but like

all other vapors is condensed, and held to a considerable extent, by dry earth.

In the experiments at first made with this substance (which is used on the large scale for the extraction of sulphur from its ore, and of oils from oil-cake) it was found that, while it is very prompt in its action on the Phylloxera, it is also liable to injure and even kill the vine roots. For some time its use in the pure form was thought to be impracticable, and efforts were made to use it in its watery solution, in combination with potash—the so-called “sulpho-carbonate” of potash. This method was measurably successful, and in some cases is still considered the best mode of application. But here, again, the necessity of using water to saturate so large a mass of soil proved a serious stumbling block, since it added to the already larger first cost of material, that of labor; to so serious an extent that the method could only be used to save very valuable vineyards.

Returning to the direct use of bisulphide of carbon, it was soon discovered that there is a certain measure of dilution of the vapor, within which it is practically without any effect on the vine, while still fully accomplishing its mission against the Phylloxera. This measure has now been ascertained by long and elaborate experiment; and by means of simple appliances that can be used by any intelligent laborer, the measure and mode of application of the liquid bisulphide to the soil of the vineyards can now be so gauged as to accomplish any desired object, from the mere repression of the insect while the vine is kept in bearing (culture treatment), to the complete extermination of both insect and vine. The latter course may be advisable when infested spots first show themselves in vineyards, with a view to stamping out the pest altogether. The former measure will, as a rule, be adopted, where the infection has already become general, and the choice lies between it and the entire loss of the vineyard in the course of a few years. Experience in France has shown that, when taken in time, the evil may be kept in abeyance at a comparatively trifling cost, by the use of the bisulphide, without interrupting the bearing of the vines. When farther advanced, the loss of one or several crops will result, even though the vines may be saved; but there is a certain point beyond which it will pay better to replant and protect the young vines, than to attempt to rehabilitate the old ones.

Rules to be Observed.

To accomplish these results, however, it is necessary to adhere strictly to the rules given as the result of the best practice, with only such modifications as may be commanded by the varying nature of the soils. These rules may be briefly formulated as follows:

I. The application of the insecticide must be made only when the soil is fully moist, though not water-soaked. In dry soil, and in the dry and warm season, the vapor is rendered inert, partly by absorption in the immediately surrounding soil mass, partly by evaporation to the surface. Moist soil absorbs the vapor but very slightly. In it, therefore, it can spread farthest, and is best protected from surface evaporation. To avoid the latter, also, the soil should not have been recently tilled.

The failure to observe these fundamental conditions of success, has been the most frequent cause of disappointment, and has led to a current notion that the treatment is inapplicable to dry climates

like that of California and the south of France. On the contrary, the most emphatic reports of complete success now come to us from the Mediterranean departments of France, whose climate most closely resembles ours.

II. Since it is the succulent white rootlets that are most liable to suffer from the effects of the insecticide vapor, the application is best made after these rootlets have hardened, in Autumn or in Winter, or before they have developed, in early Spring; even though, at these times, the hibernating and most hardy generation of the insect has to be dealt with.

III. For the culture treatment, the carbon bisulphide must be used in small doses, of one sixth to one fourth fluid ounces each, injected into holes ten to sixteen inches deep,* which must be instantly closed on the removal of the "injector."† Of these holes there must be at least three per square yard of vineyard surface, regularly and evenly distributed; say ten to twelve thousand holes per acre. As an approximate measure of the speed and cost of such proceeding, it is stated that two ordinary laborers, working together, finish off about three hundred holes per hour.

IV. When the "death treatment" is intended, the number of holes, or the dose of the insecticide, or both, are to be increased in a ratio that varies with the nature of the soil. Say, for example, fifteen thousand holes per acre, and in each fifty per cent more of the liquid.

V. In beginning the treatment of a badly infested vineyard, it is advisable to repeat the injections after the lapse of ten or fifteen days. When this is intended, smaller doses than the above may be used, and the second set of holes should be intermediate between the first.

The cost of one "culture" treatment in France is given at eighty-seven and one half francs, or about seventeen dollars and fifty cents, per acre; that of two treatments, with diminished dose of the liquid, at one hundred and twenty-five francs, or say twenty-five dollars. This is on the basis of sixty cents daily for each laborer, and four and one half cents a pound for the bisulphide, wholesale—from two hundred and fifty to two hundred and eighty pounds per acre being used.

From these data it will be easy to determine approximately, beforehand, the cost of treatment with bisulphide, under the prices for labor and material prevailing in this country.

VI. The insecticide treatment of infested vines should always be accompanied by the use of appropriate manures, in order to strengthen the vitality of the vine and thus increase its resistance, both to the Phylloxera and to the influence of the insecticide. The nature of the manures required is indicated by the chemical analysis of the juices of the healthy and diseased vines. It has thus been shown that the change caused by the attack of the Phylloxera con-

*The depth of the holes should be increased in proportion to the perviousness of the soil, which increases loss by surface evaporation.

† This injector consists of a hollow iron handspike, pointed, with cross-handle and foot-rest, for effective use. To this is attached a reservoir, containing about a quart of the bisulphide, closed at base by an adjustable piston-gauge valve, by whose action a dose of the liquid is ejected from an opening near the point of the spike, when the latter is withdrawn from the hole. The tool for closing the latter is a solid iron handspike with a hollow cone or cup at the lower end.

sists mainly in the diminution of the potash and albumen normally contained in the juice; also in that, instead of crystallizable sugar, the abnormal juice contains chiefly or wholly the variety called glucose.

It was thus indicated that manures rich in potash and nitrogen, should be used, in order to enable the plant to maintain as nearly as possible the normal condition. Experience has abundantly justified this important conclusion. In numerous cases (probably in soils poor in potash and nitrogen, or from their sandiness not very favorable to the Vine Louse) the use of these manures alone has so far improved the condition of the vines, as to neutralize the injury done by the insect, and restore them to their usual productiveness. In all cases, when the vines were not too far gone, their condition has been materially improved by the application.

Potassic manures appear to exert the most decided effects; and fortunately, the material which most cheaply supplies this important substance (*Kainite*) can now be readily obtained in commerce. Wood ashes, wherever obtainable, are of course equally well adapted to the purpose.

On strong clay or adobe soils a dressing of quicklime will produce, for the time being, an effect similar to that of the direct application of potash manures, while at the same time it will facilitate tillage, and impart to the soil the qualities of those on which the best of wild vines are usually found.

Next in efficacy to potassic manures are those supplying nitrogen, especially in the form of ammonia. In selecting these it should be borne in mind that most of the compound ammoniacal manures of commerce contain this substance in connection with phosphates. These, however, in general, are of subordinate interest in the case before us, as proven by experiment as well as analysis. It is obviously best to throw whatever outlay can be afforded in the direction where it will do the most immediate good, by supplying the ingredients chiefly needed. The commercial sulphate of ammonia, now abundantly and cheaply obtained from gas-water, seems to be one of the most available materials for the purpose. All refuse animal matter answers the same object; and so, to a considerable extent, does Chilian saltpeter.

As a matter of course, stable manure answers this, as it does almost every other purpose for which manure is wanted. The only question is, how to get enough of it—the problem which agriculturists have been trying to solve from the most ancient times to the present.

Since everything that tends to strengthen the vitality and development of the vine, increases its power of resisting the attacks of the enemy, and correspondingly increases its ability to produce crops despite of the drain upon its juices, thorough and careful culture at the proper time is to be considered as one of the necessary elements of success in the struggle. This point is not made very prominent by the French Commission, because French cultivators are habitually diligent in this respect. But as this is far from being the rule on this side of the Atlantic, an express admonition can hardly be deemed superfluous. Thorough tillage is cheaper than manuring, when the manure has to be bought; and on our unexhausted soils it will to a large extent replace the latter. That deep tillage is especially important in California, on account of the long dry season, hardly requires discussion.

The question as to whether it will *now* pay to manure and cultivate the vineyards thoroughly, I will not discuss at length. The present state of our viniculture is in so many respects anomalous, that it can hardly be taken as a safe basis for estimates of what may be, even a few years hence.

In the natural course of things California can hardly fail to become one of the foremost grape-growing countries of the world, since it possesses all the natural advantages for this branch of industry that can be imagined. The agriculture of all countries must, after a short period of exhaustive culture, be carried on on the basis of returns to the soil in the shape of manures. Even our Western and Southern States are fast coming to this, and California will have to do so in her turn; first commencing with such crops as from their high value and sensitiveness as to quality, will best pay for high culture. The grape crop is preëminently one of these.

In any case, the question will soon arise, whether owners of vineyards can better afford to manure, or to lose their investment. Those who are now suffering from the ravages of the *Phylloxera*, will doubtless be able to throw some light on the question.

There are two other modes of applying the carbon bisulphide, that have been measurably successful in practice, and may present advantages in certain cases.

One is, to absorb the liquid bisulphide into porous bodies, such as wood or clay, which are then buried in the soil near the vines. From them, a slow diffusion of the vapor takes place, sufficient to kill the parasites, but not to injure the vine roots. The most successful application of this principle is that of the "*Cubes Rohart*" or *Phylloxera* bricks; prisms of half-baked, porous clay, filled with the liquid insecticide under pressure, and then coated with glue to prevent evaporation, until the glue is softened by the moisture of the soil. The operation of introducing these Rohart bricks into the soil, being the same as in the case of the liquid bisulphide, it is obvious that the entire expense of their manufacture is in excess of the cost of the use of the liquid insecticide; the only advantage being that in no case can the vine roots be injured by the very slow evolution of the poisonous vapor. But, since experience has shown that the same result can be achieved by an adequate subdivision of the liquid doses, there is little probability that any such indirect mode of application will hereafter be preferred.

The sulpho-carbonate of potassium has already been mentioned as one of the forms in which bisulphide of carbon may be applied. It being rendered soluble in water by combining it with sulphide of potassium (liver of sulphur.) The preparation of this compound is somewhat complex, though not very costly. It ranks next to the carbon bisulphide as a cheap and effective insecticide, but it is not quite as harmless to the vine roots, and its application, by means of water, is more laborious and costly. But, there are cases in which it is nevertheless preferable. It sometimes happens that in very pervious soils, in which the bi-sulphide must be injected to a considerable depth, the insects clinging to the most superficial roots are not killed, in consequence of too ready access of air, by which the poisonous vapor is so diluted as to be ineffectual. In such cases, water charged with about one eight-thousandth of its weight of the sulpho-carbonate, is an effectual and comparatively

cheap surface application, the soil being moistened with it to a depth of six to ten inches only. It is therefore very desirable that this compound, also, should be accessible to vine-growers.

Other Insecticides.

Of other insecticide applications that may be available and useful in certain cases, it will suffice to mention a few that have proved to be of some practical utility.

Coal tar and *crude carbolic acid* have from the first been prominent among the antidotes suggested; and while they have failed to perform all that might be desired, there can be no doubt that they may advantageously be used as repressive agents, to impede or prevent the migration of the wingless insect over the surface of the ground, as well as the flight of the winged form. These objects are, to a considerable extent, accomplished by sprinkling the surface of the ground thickly with sawdust, or similar material, previously impregnated with tar, or tar water; the operation to be repeated from time to time, as the odor evaporates; a somewhat thicker dressing of the same material to be applied around the stock of the vine. Application of the same to the exposed surface roots does not seem to pay for the additional trouble by increased effects; and too direct contact of the tar with the rootlets injures or kills the latter.

Soot may be similarly used; its effects are advantageous in other respects, and there is no danger of injury to the vines.

Gas lime, from the purifiers, must be used with great caution. Its effects, due to the combined action of the tarry substances and of sulphur compounds (the latter giving off "sulphuretted hydrogen" in the soil) are so energetic, that the vine may easily suffer as much therefrom as the Phylloxera. It may be applied mixed in moderate quantities with the tarred sawdust, or scattered over the surface sparingly by itself.

Sulphuretted hydrogen, generated in the soil on the application of the sulphur compounds of some of the metals, etc., is a very energetic insecticide, but scarcely less dangerous to vegetation, unless its action is made very brief. It is instant death to insects, while plants recover, after some time, from the effects of a brief exposure to its action. Hence its availability for the destruction of the Phylloxera, if used with great caution. So much permanent injury, however, has resulted from the improper and excessive use of sulphides, that their application by inexperienced hands is mainly useful for the purpose of exterminating the insect in ground which is to be replanted in vines, after the removal or death of infested stocks. Where the residues of soda manufactories are available, this can be done at a cost not exceeding that of transportation and application. Otherwise, suitable materials are not ordinarily obtainable at a low cost, apart from the gas lime, already referred to.

PREVENTIVE MEASURES.

Whatever may be the conclusion reached in respect to the profitability of maintaining or restoring badly infested vineyards, there can be no possible doubt in regard to the action to be taken in districts not yet invaded. Since the attack always proceeds from a few well defined and easily recognized centers, a close and unremitting

watch must be kept over every vineyard in each region, in order to detect the invasion in its first beginnings; when a few pounds of the insecticide, coupled with a few hours of intelligent work, will at once put an end to the immediate danger of farther spreading of the pest. The transportation of vineyard products, and especially of cuttings from infested regions, should be closely guarded, and a preliminary disinfectant treatment with bisulphide vapor applied in any case of doubt. Wagons, agricultural implements, and even the clothes of persons working in infested vineyards, may carry the eggs of the insect from one vineyard to the other, or from infested portions of one and the same to the sound portion.

It is thus obvious that sanitary regulations similar to those practiced in respect to other contagious diseases, should be established and enforced in regard to the Phylloxera pest. No one should be allowed to disregard or consider himself exempt from such regulations, and their infringement should be visited with the same reprobation or penalty that would attach to the violation of the sanitary rules regarding smallpox or yellow fever. Above all is it needful that no one should be permitted to hide the fact that his premises are infested, since the precautions adopted for the common welfare would thus be rendered nugatory. Any sale or pecuniary transaction based upon a wilful concealment of such fact, would be morally, and should be legally, considered as tainted with fraud.

It is now known that the infested region forms a broad belt across the State, from Sonoma to the Sierras, the northern limit being from the head of the Sonoma Valley proper, below Bennett Valley, across to Yountville, in the Napa Valley, and thence to the neighborhood of Placerville; while the southern limit seems to be, thus far, the north shore of the bay, the Sacramento and American Rivers, American River in the valley; in the foothills, south of the same. But one infested spot is known north of Yountville, and this there is reason to hope will be promptly stamped out. It is for those living outside of the above limits to see that the enemy is not carried into their vineyards, either by carelessness or intentionally, and with the aid of the measures suggested above this can unquestionably be done.

"Eternal vigilance" will be found in this case, as in others, the cheapest price at which exemption from the pest can be purchased. Any vine showing symptoms of disease should be at once examined, especially on its outlying white rootlets, in order to detect the swellings that form the mark most readily recognized by the naked eye. Upon these, also, the minute yellow insects are most easily seen. An infested spot will soon appear as a basin-shaped depression in the generally leafy surface of the vineyard. Of course, such spots may result from other causes, such as poor or shallow soil, lack of drainage, etc. In their examination for the presence of the Phylloxera, not only the vines within the depression should be examined, but also those located two or three rows beyond, since, as already stated, the insect prefers strong and healthy vines for pasture, and will entirely abandon weak ones long before they die.

Any good eye can detect the characteristic marks of the Phylloxera, when once accustomed to the search; but by the aid of the lens, and a comparison with the figures given above, little doubt can be left in most cases. In case of doubt, specimens sent to the University will be examined and reported upon. But in their transmission great care should be taken to prevent an accidental scattering of the con-

tents of the package. A few rootlets, or root fragments, should be inclosed in a small vial, filled with moist earth; this, well stoppered and then inclosed in a bored wooden block, forms a safe package, which can be sent by mail at a trifling expense.

OUR FUTURE VINEYARDS.

However important it may be to save the vineyards now existing, the problem of rendering those to be planted hereafter, proof against the attacks of the Phylloxera, deserves no less serious consideration. Fortunately, the thorough studies made in the East and in Europe on this subject, show us a plain and inexpensive way to the attainment of this great desideratum.

The fact that the Root Louse does not attack the roots of certain grape varieties, while the Gall Louse is equally unable to live on the leaves of others, at once suggests the grafting of the latter varieties upon the former as an effectual remedy against the depredations of either form of the Phylloxera.

The practical application of this principle has already been widely tested, both in the East and in Europe; and in most cases with the happiest results.

Cases of failure have also been reported, and these appear to be reducible to two classes. The first and most numerous is that which is referable to the inattention of observers to the necessary precaution of preventing the scion from *casting roots of its own*, by grafting sufficiently above ground, instead of on the root, as is the usual practice in grafting grapevines.

A second but less numerous class of failures seems to have resulted from actual differences in the kind and degree of susceptibilities of the varieties used, from that experienced in other localities. At first sight this appears an alarming result; but it loses much of its seriousness when we reflect how strongly the nature of the soil, as well as the accidental character of a season, may have influenced both the original determination of the character of the vine in relation to the Phylloxera, and the subsequent contradictory experiments. It is contrary to all experience to suppose that the vine, in its relations to the Phylloxera, should act differently from what it—as well as all other grafted stocks and scions—is known to do as regards every other peculiarity. The facts before us, however, are sufficient to warn us that before determining upon the proper stocks and scions for our vineyards, somewhat extensive and prolonged experiments should be made; and that not only at one locality in the State—least of all at one where, as is the case at Berkeley, the grape does not succeed under ordinary circumstances—but in each of the chief vine-growing districts of the State. In the meantime, only such stocks as have proved to resist the Phylloxera most completely, under all circumstances, should be chosen as the basis of new vineyards.

The following table, taken from Professor Riley's reports, exhibits the result of experience in the Eastern States concerning the relative powers of resistance of the most important grape varieties, to the Root Louse. The relative "importance" indicated in the table, refers, of course, to the general estimate of the wine-making qualities and hardiness of the varieties, in the climate and soils of the Western States—especially Missouri, Illinois, and Ohio. For California these estimates may require modifications, which must be determined by experience.

TABLE OF GRAPE VARIETIES.

EXHIBITING THEIR RESISTANCE TO THE PHYLLOXERA.

A.—Recommended for use as stock to graft on, because not liable to the Root Louse.

- | | |
|----------------|-----------------------|
| 1. Concord, | 5. Norton's Virginia, |
| 2. Clinton, | 6. Rentz, |
| 3. Herbemont, | 7. Cynthia, |
| 4. Cunningham, | 8. Taylor. |

B.—Varieties to graft on the above—very liable to the Root Louse.

Of First Importance:

- | | |
|--------------|--|
| 1. Catawba, | 4. Wilder, |
| 2. Iona, | 5. Goethe, |
| 3. Delaware, | 6. All European Grapes
(including Mission). |

Of Secondary Importance:

- | | |
|----------------|-----------------------|
| 7. Ives, | 9. Hartford Prolific. |
| 8. Maxatawney, | |

Fortunately, the two varieties most highly esteemed in the Mississippi Valley for their wine-making qualities and hardiness, are also first among those enjoying immunity from the Root Louse. It might thus fairly become a question, whether some of these American varieties should not bodily be substituted, to some extent, to the varieties of the European stock, now almost exclusively cultivated in California. But there can hardly be a question as to the propriety—not to say necessity—of using these hardy varieties as stocks whereon to graft the more delicate ones we may wish to retain on our list. That the Concord and Clinton, as well as the Catawba, Isabella, and other American varieties, make a vigorous growth in California, experience has already demonstrated, perhaps at the cost of introducing the Phylloxera into the vineyards of this coast. We may as well now try to profit by the experience so dearly bought; the more as the Mission grape is not, assuredly, in itself a desirable wine grape.

Among the resistant stocks most readily available to California grape growers, the native wild grape, *Vitis Californica*, deserves earnest attention. In its botanical characters it stands near the wild species from which the Clinton and Taylor are derived; and while it does not seem to harbor naturally either variety of the Phylloxera, experiments made by planting it among infested vines, seem to show that, although some insects will migrate and attach themselves to its roots, it does not suffer in any sensible degree from this attack. It should be understood that under similar circumstances the roots of the Clinton and Taylor are also visited by the insect, but without injuring vitality. Experiments as to the facility of propagation, adaptability to grafting with the most desirable varieties of the European stock, etc., are now in progress, both at the experimental grounds of the University, and by private parties, so that certainty on these points will not be long delayed. Naturally, also, the Californian wild grape seems to promise well for development into a desirable claret wine grape, and experiments on all these points cannot be too widely repeated.

The expense of using grafts in planting out vineyards is, of course, somewhat greater than when simply rooted cuttings are set out. But this is a trifling consideration when an investment which is to last for thirty or forty years is at stake. Grafting the vine above

ground is not by any means so precarious an operation as is supposed by many, and may be accomplished successfully in a variety of ways, the most important of which are: 1. Grafting the rooted cuttings; when carefully done, especially using canes of the same diameter, in good seasons but a small percentage fails. 2. Grafting by inarching; this is applicable to older vines, and is done by inserting both ends of the scion, sharpened, into cuts made in the stock so as to cause the former to be elastically retained. The scion so placed rarely fails to "take," and the stock and scion can be severed at leisure between the joints. 3. Another mode, strongly recommended in the West, is to plant two cuttings (stock and scion) about a foot apart, and as soon as the canes of the first year's growth have sufficiently ripened, join together firmly by smooth-cut surfaces, and after they have united, cut the connection between the scion and its root. This mode is of course infallible, as it can be repeated should the first joint fail to "take."

Either mode of proceeding, of course, to be successful requires precautions which I cannot here consider at length. One essential point, however, is that cleft grafting is ill adapted to American canes at least, and probably to all.

FACILITY OF PROPAGATION.

An important point to be considered in this connection is the facility with which the several stocks and scions recommended may be propagated in the cheapest manner, *i. e.*, by rooting cuttings; it being obvious that propagation, by layering, if necessary, would materially increase the first cost of a vineyard. On this subject the subjoined table (furnished by Mr. George Husman, the veteran Missouri viniculturist, to Professor Riley), will convey important information:

TABLE OF GRAPE VARIETIES.

EXHIBITING FACILITY OF PROPAGATION BY CUTTINGS.

A. Practically not propagable by Cuttings; must be Layered.

- | | |
|-----------------------|---------------|
| 1. Herman, | 3. Cynthiana. |
| 2. Norton's Virginia, | |

B. Quite difficult to propagate from Cuttings.

- | | |
|----------------|---------------|
| 4. Herbemont, | 7. Rulander, |
| 5. Cunningham, | 8. Louisiana, |
| 6. Devereux, | 9. Delaware. |

C. Cuttings, root with tolerable ease.

- | | |
|----------------|-----------------|
| 10. Eumelan, | 12. Maxatawney. |
| 11. Creveling, | |

D. Cuttings root easily.

- | | |
|------------------------|--|
| 13. Hartford Prolific, | 20. Rogers' Hybrids (Goethe, Massasoit, Wilder, Lindley, Agawam, Merrimac, Salem, etc.), |
| 14. Telegraph, | |
| 15. Ives, | |
| 16. Concord, | |
| 17. Catawba, | 21. Arnold's Hybrids (between Foreign and Clinton.) |
| 18. Iona, | |
| 19. Diana, | |

E. "Root like Willows."

- | | |
|--------------|-------------|
| 22. Clinton, | 23. Taylor. |
|--------------|-------------|

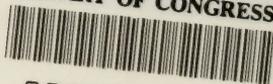
It will be observed that here, again, the Clinton and Concord stand among those offering the greatest advantages; the former, with the Taylor, preëminently so. It would thus seem that, so far as experience goes, these two varieties offer the best prospects for the solution of the important problem before us.

Of late the propagation of vines by means of seed has been considerably discussed and experimented upon. It has been contended by some that the attack of the Phylloxera is due, not to its introduction from America, but to a gradual weakening of the vitality of the vine by long continued cultivation, and especially propagation by cuttings only.

While the array of facts carefully observed and compared, seems conclusive against this view (which is most especially inapplicable to the American grape varieties but lately taken from the woods, and yet quite as sensitive to the attack of the insect as any of the European varieties), yet it is indisputable that vines grown from cuttings offer points of weakness not present in a normally grown seedling. The root system of the latter is more copious, more widely and deeply spread, and its crown does not offer a point of weakness and a favorable locality for a nidus of the attacking insect, such as is presented by the old cane surfaces between the several joints from which the roots have sprung in the cutting. It is even contended by some that the seedlings "come true" to the parent variety, to a very great extent. While the latter claim may be very gravely called in question, as contrary to all past experience, it may well be worth the while of the grape grower to give to his vines the additional vigor and security afforded by their being seedlings instead of rooted cuttings, when intended as stocks for grafting. In other countries this practice is considered as involving a year's delay in the bearing of the vine. But at least as regards the wonderfully rapid-growing native wild vine of California, this may well be called in question. Seedlings grown from seed furnished by C. A. Wetmore, Esq., of San Francisco, who has given this subject very particular attention, to the University, have this season, eighteen hundred and eighty, between March and November, reached a height of twenty inches, and a thickness of as much as one half inch at the point above the root-crown where they will be grafted, next season, with scions of all the grape varieties most desirable for culture in California. But whether propagation by seed or cuttings shall prove the more desirable method, the *Vitis Californica* promises at this time a most satisfactory solution of the question of resistant stocks for the Vineyards of the Future.



LIBRARY OF CONGRESS



00014557386

