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LECTURE ON THE PHYLLOXERA* OR GRAPE VINE LOUSE,

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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 lecture.

It was first observed in America in 1856, by Asa Fitch, of New York, and by him named *Pemphigus vitifoliae*. Other names were subsequently applied by other observers to its various forms, until, about the year 1870, their identity was demonstrated by Lichtenstein, Riley and others.

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

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 1865-6, was shown to be due to wingless lice in 1868, 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 1870 to 71, 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 varieties in the Mississippi valley, observed long since, was due to the attacks of the Root Louse.

When, not many weeks ago, I was examining 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 1870 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. Four years ago 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 and Portugal. Universal alarm has been created in these countries, and the literature of the subject has become exceedingly voluminous.

In 1873, 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, 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 illustrations of the present lecture.

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 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 louse, one twenty-fifth of an inch long. 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 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 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. 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 aliment-

ary 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 reproduction, for five or six generations.

So far it would seem as though the reproduction 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.

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 indispensable 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 *Frost Grape*, seems to be best of all adapted to the taste of the Gall Louse. In the South I have seen whole arbors of this grape (*Vitis riparia*) 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.

On grape varieties whose leaves are not to its taste, the Phyl-

loxera 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 depends 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 Frost 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 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. æstivalis*), such as Concord, 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 insect appears in countless numbers, in July and August. It does not seem to possess great powers of flight; but it is so light and the wings so large in proportion to its 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, and which, together with larva, 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 succers. 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 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 is thought that this prompt decay is induced by an excrement that the animal injects into the wound, perhaps to promote the flow of sap.

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 form 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, whose

significance 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 vine ordinarily succumbs sooner than a strong 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.

COMBATING THE PHYLLOXERA.—1. SUBMERSION.

I have already stated that the prize of the French Government for "an efficacious and practicable remedy" for the ravages of the Phylloxera has not yet been awarded. Several of the remedies suggested fulfil *one* of these two indispensable conditions; and there is one which for a not inconsiderable class of localities fulfils both. This remedy is *submersion of 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 *two* 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 hibernating 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.

The facts just mentioned offer a ready explanation of the very rapid progress made by the Phylloxera in California during a single season. 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 the most energetic measures be at once taken, the fate of our vineyards may reasonably be expected to be worse than even that of which the French complain so grievously.

2.—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, or stop its under ground communication through sun-cracks and *along the roots which interlock between the rows*. Unless therefore the application of sand is carried to the ex-

tent 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.

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.

3.—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 a tendency of most of them to injure the vines quite as much as the *Phylloxera*. I shall therefore mention only those whose utility is proven beyond question.

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 coal tar; the operation to be repeated from time to time, as the odor evaporates; a somewhat thicker dressing of the same ma-

terial 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 sulphids, 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.

The use of *phosphoretted hydrogen*, or of substances generating it in the ground, is liable to the same objections as that of the sulphur compound, is more expensive in its materials, and seems to offer no advantages not possessed by the other.

Another sulphur compound which at first was thought to possess all the requisite properties, is the *bi-sulphid of carbon*. This substance, now extensively used in the arts as a solvent of sulphur, india rubber, etc., is cheaply obtained by passing the vapor of sulphur over red-hot charcoal contained in a retort, and condensing the very volatile vapor that is so formed. The resulting liquid, colorless when pure, is so volatile that it boils at a temperature but little higher than that of the hand. Be-

ing, moreover, highly inflammable, and very injurious when its vapor is inhaled, it is obvious that it is not a substance which can be safely entrusted to inexperienced hands.

For years past this compound has been employed in France in the extermination of rats, especially in the sewers of cities. Its vapor, which is far more deadly to small animals than to man, is moreover so much heavier than air, that it flows down into rat-holes just as water would do, and effectually destroys the inmates. It might doubtless be used with equal advantage against the *California Ground Squirrel*, if it could be cheaply supplied.

To insects it is instantly fatal, even in very minute quantities; while to plants it is very much less injurious than sulphuretted hydrogen.

For some time it was thought that the direct application of this substance to the vine roots might solve the problem of the extermination of the vine louse. It was applied by pouring about a gill of the liquid into holes punched deeply into the ground around the vine, afterwards plugging them with earth. But it was soon found that this mode of operating not only injured the vines by the great excess at the points of application, but was moreover only very partially effective; since the poisonous vapor failed to reach the outlying rootlets, from which the rest of the vine was promptly re-stocked. It was found necessary to apply the antidote to the entire surface of the field; and this required such large amounts of the substance as to render the cost excessive.

Both objections to the use of the carbon bi-sulphid were, however, finally overcome by first combining it with an alkaline base—potash or soda—so as to render it soluble in water, and capable of being used in very dilute solution. The nature of these compounds is such that when applied to the soil, the carbon bi-sulphid they contain is set free very gradually (together with some sulphuretted hydrogen); not enough at any one time and place to injure the vine roots, yet sufficient to effectually kill the vine louse, eggs, larvæ and all. As the dilute solution can be used abundantly, it penetrates into the soil to a correspondingly greater depth than would the bi-sulphid, when applied directly in comparatively small quantities. The gravity of the vapor will, in either case, carry the effect much deeper than the solution itself may penetrate.

The strength of the solution most suitable for practical pur-

poses was found to be one part of the dry compound in eight thousand of water. The substance is furnished by the manufacturers in the shape of a strong solution, containing equal parts of water and compound, or fifty per cent. strong. This can be shipped in cases to any distance.

Previous to the application of the liquid, the ground should be very thoroughly tilled, so as to allow the antidote to penetrate as rapidly as possible. It may be interesting to mention in this connection, experiments made with a view to testing the effect of dynamite explosions in loosening refractory soils. Water was standing on the surface of a vineyard plot to which the antidote was to be applied: small dynamite cartridges were exploded at the depth of two or three feet, the result being that the water immediately disappeared from the surface, and the soil appeared as though it had been trenched or underdrained. Where the latter operations are as expensive as they are in California, this novel mode of producing substantially the same results may not be unworthy of a more extended trial.

As to the expense of a thoroughly effective application, it is found in France to amount to about ten to fifteen dollars per acre. There are, of course, considerable differences in the amount required on different soils, according to their degree of penetrability, and the depth to which the roots of the vines reach. The amount needed on any given soil may be estimated upon the basis that, according to numerous experiments, one pound of the sulpho-carbonate of potash, will kill every insect in from one thousand to fifteen hundred cubic feet of earth. On the supposition that the effect of the antidote must be made to reach to the depth of three feet, each vine in a vineyard planted eight by eight feet, would require the impregnation of two hundred cubic feet at the rate mentioned, or one pound of the sulpho-carbonate to every five to seven vines. This is doubtless a maximum estimate, applicable to old vines strongly infested. The insect, arriving at the vine from the surface or through surface cracks, attacks first the roots located near the surface: and may therefore be most readily reached and destroyed in the early stages of its onset. As usual when the application of the remedy is too long delayed, the cure becomes more difficult and expensive, and even impossible or at least unprofitable, when the evil is not taken in time.*

*The above data are based on determinations made on a small scale. The latest re-

The French commission distinctly aver, that the reported cases of failure to accomplish the expected result of the use of the sulpho-carbonates, are almost always directly traceable to either a failure to conform to the rules prescribed as requisite to success, or else to the fact that the vines were too far gone to be much benefited by the destruction of the insect. The antidote, while not materially detrimental to vines in moderately good condition, is not altogether innocuous, so that the effect of its presence on very weakly stocks is noticeable. It is therefore urgently recommended that in this as in every other case of a serious disease, *timely* measures be taken.

In view, however, of the fact that the liberation of a small quantity of sulphuretted hydrogen in the soil is unavoidable when the sulpho-carbonates are employed, another class of compounds whose decomposition in the soil is unattended with this evil, has lately come into use. These compounds (called Xanthates), whose efficacy depends equally upon the liberation of carbon bi-sulphid in the soil, contain as an essential ingredient either alcohol or wood-spirit, and on that account would be very expensive in the United States; while the manufacture of the sulpho-carbonates could be cheaply accomplished even in California.

NECESSARY PRECAUTIONS.

The French commission emphasizes the following points to be observed in the application of either sulpho-carbonates or xanthates, as necessary to success.

1. *Application in spring or autumn*, at the time when vegetation is not very active; to prevent as much as possible the effect of the antidote upon the delicate rootlets, and its consequent absorption by the vine.

2. *Application in sufficient quantity at one and the same time*,

port on the application of the process on a large scale was made by M. Ducloux to the French Academy, on November 8th. About three and one-half acres were treated with the sulpho-carbonate solution, allowing fifteen vines to each pound of the compound, or double the number estimated above for a depth of three feet. Six and one-half gallons of water were used for each vine. The result was not a single living insect could afterwards be found, even on the deepest roots: but their remnants appeared in the shape of thin pellicles still hanging on by their suckers. The vines had not suffered in the slightest degree.—On another plot, at Villié, previously treated, the vines were in a flourishing condition, but a few scattered individuals seemed, from some cause, to have escaped the action of the poison. The nature of this course is undergoing investigation.

and if possible *before a rain*, so as to favor the absorption by the soil as much as possible. The decomposition of the compound in the soil is accomplished in the space of about three to four days, and the farther it penetrates during this period the better.

3. The use of insecticides must, *in all cases*, be accompanied by that 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 consists 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 syrupy 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.

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 the most available material for the purpose. All refuse animal matter answers the same object; and so, to a considerable extent, does Chilian saltpetre.

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 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.

It has been very broadly and confidently asserted, that an insect enemy of the Phylloxera has been discovered in the West, by Planchon, who carried some of the living antidote to France, expecting thereby to exterminate the Phylloxera. These reports are a gross exaggeration of the facts, as well as of Prof. Planchon's views. The insect in question could hardly be expected to accomplish in France what it has signally failed to do in its native clime; and the fact that after it was turned out on its "mission of death" by Planchon, the "destroying Acarus" (or rather *Tyroglyphus*) was found to have been already naturalized (having probably been introduced at the same time with the Phylloxera), shows conclusively that it cannot be relied on, save as a useful ally; whose services we should of course secure, if it is not already busy on our infested vines.

NECESSITY FOR ACTION.

It will be said, and I have heard it said by a good many, that there is no real cause for all this alarm about the Phylloxera. That the damage done so far in California is insignificant; and that from France, after all the outcry raised about the ruin of the vineyards, we have reports of one of the largest crops ever made. Finally, if we are to go about all this trouble of poisoning and manuring, vine culture will be a losing business, and had better be let alone.

That the damage so far done in California is comparatively insignificant, is fortunately true. That it will remain so if the matter is let alone, is improbable to a degree which only those who have taken pains to follow up the history of the subject, can fully appreciate. Whether we look to France, Austria, or to the long defunct Catawba and Isabella vineyards of our Western states, we find the same tale of rapid destruction whenever the disease has gained any headway, though at times temporarily checked by a season unfavorable to the development of the insect. So far as rapidity of progress and thoroughness of work goes, the beginning made in Sonoma during the last few years compares favorably with any observed elsewhere; and unless we are satisfied, like the ostrich, to hide our head in the sand, in hopes of thus eluding the pursuer, it is high time that energetic and concerted measures were taken in the premises. It is such action, based upon intelligent scientific investigation, that has enabled the infested districts of France to participate in the abundant crop of the past season. Although the use of insecticides has been far from universal, the more careful treatment of the vineyards which followed the general alarm, as well as the intelligent precautions taken against the farther spread of the pest, has been followed by results which cannot but be very encouraging to us—not as justifying a farther neglect of precautions, but as showing what earnest and combined effort can accomplish, even against such formidable odds.

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. The average quality and market value of Californian wines is now far below

what it should be, and can doubtless be *made* to be, with a more careful selection of grape varieties and methods of treatment. The fact that they do not conform to the taste of wine-drinking nations, limits our market. The distillation of brandy from the pommace and inferior grapes and wines, from which the profits are often mainly derived in wine-growing countries, is now so hampered by the revenue laws, that it scarcely counts as a source of income to the vine-grower. All this will soon be changed, and in the natural course of things California can hardly fail to become one of the foremost wine-producing 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 wine crop is pre-eminently 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 in Sonoma, will doubtless be able to throw some light on the question.

WHAT SHOULD BE DONE?

But as the matter now stands, the formidable expense of poisoning and manuring need not be incurred on any large area, if a united effort, strengthened, perhaps, by appropriate legislation, is brought to bear on the limited region thus far known to be infested. By energetic action the pest could most probably be confined to its present range; and attention and early precautionary measures on the part of all interested, could prevent a recurrence of any considerable development of the evil. For the present emergency it would perhaps be best to import an adequate supply of the antidote from France, where it is now manufactured on a large scale; but in the future, it is to be hoped that the demand will be supplied by home manufacture, since its chief material (sulphur) is a cheap home product.

OUR FUTURE VINEYARDS.

However important it may be to save the vineyards now existing, that 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 grape vines.

A second but much 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 any ordinary circumstances), but in each of the chief vine-growing dis-

tricts 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 Prof. 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 Phylloxera 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 RESISTENCE TO THE PHYLLOXERA.

A.—RECOMENDED 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. Cynthiana,
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,	

Since the succession of numbers in the above table indicates the estimated comparative degrees of resistance, it will be seen that the two varieties most highly esteemed 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 a large extent, to the varieties of the European stock, now almost exclusively cultivated in Cali-

ifornia. 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, 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.

Should the Eastern grapes now considered as proof against the Phylloxera turn out to be less hardy, or otherwise unsuitable to this climate, the native wild grape of California may, perhaps, be made to answer as a stock; and experiments in that direction cannot be too soon begun.

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 years 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 Prof. 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,	19. Diana,
14. Telegraph,	20. Rogers' Hybrids (Goethe, Massasoit, Wilder, Lindley, Agawam, Merrimac, Salem, etc),
15. Ivès,	21. Arnold's Hybrids (between Foreign and Clinton).
16. Concord,	
17. Catawba,	
18. Iona,	

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*, pre-eminently 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—

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a problem which, I fear, is more pressing than *any* now engaging the attention of our viniculturists.

OBSERVATIONS REQUIRED.

It is much to be desired that as many observers as possible should, during the coming season, pay close attention to the habits of the Phylloxera in this climate. The much-to-be-dreaded winged form of the insect has not thus far, it seems, been observed in Sonoma. The fact that, although making fearful work where it exists, the pest has not spread quite as rapidly as the favorable circumstances would lead one to expect, leaves room for the question, whether the winged form is as abundantly produced in California as it is elsewhere. It would be exceedingly important to have so essential a point settled as quickly as possible, since on it depends largely both the nature and extent of the means that may successfully keep the Phylloxera in check.