THE

Resistant Vine Question

FOR

CALIFORNIA

AND THE

California Vine or Anaheim Disease

BY

H. HOOPS
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CHAPTER I.

THE RESISTANT VINE QUESTION IN GENERAL.

The most important characteristic and the most consequential in its effect in different ways, which all species of the grape vine have in common, is their extreme and peculiar sensitiveness to temperature conditions of the soil and the atmosphere and generally much more the sensitiveness to such conditions of the former than of the latter. The scope of this sensitiveness of either the root or top varies very much with the different species, varieties and hybrids; in fact there are no two of these which are exactly alike in this respect, but it is always within well-defined boundaries. In comparing this sensitiveness of the root with that of its top of different vines, we find a multiplicity of combinations, which are most remarkable and if it were possible, that they could be well understood in every case, would remove obstacles, which at the present time, appear almost unsurmountable.

My attention was first called to this some years ago, when I compared the behavior of certain varieties, planted on soils, presenting different temperature conditions during spring and with a surrounding atmosphere, which also showed a difference in this respect. In one locality which I shall call A, the soil is gravelly and somewhat loose, and in the other locality, which I shall call B, the soil is a clay-loam, capable of holding a great amount of water in suspension during spring. But while at B, the temperature of the overlying atmosphere is uniform and generally warm during spring, A is known as having cold and frosty nights at that time, although during the middle of the day the temperature of the two respective atmospheres is about the same. A has a soil which warms up readily during spring, but an atmosphere which is exceedingly cold at times. B has an atmosphere which is uniformly mild. Of the leading table grape varieties the Tokay starts growth first at A and last at B. The Cornichon starts growth first at B and last at A. The Lenoir starts growth exceedingly early during spring at A and makes almost all its seasonal growth within about a month after starting. At B it starts growth later, but still slightly ahead of the Cornichon and then grows steadily all summer. This should prove conclusively that the scope of sensitiveness of root or top of the Lenoir, Tokay and Cornichon is not the same. In a similar

manner every species, variety and hybrid possesses a scope of sensitiveness of root and top to conditions of temperature, considered either separately or conjunctively, which is different from that of any other species, variety or hybrid.

HABIT OF GROWTH.

The peculiar sensitiveness of the grape vine to temperature conditions would not deserve the amount of consideration, that it does, if it did not exert its influence in other directions, which makes it of the greatest consequence in regard to size, vigor, hardiness and other qualities of the grape vine. Its most important influence it probably has on the growth habit of a vine, which seems to be principally governed by it. A vine which is affected by a certain degree of coldness more than another one, provided other things, as form of root system, size of roots and nature of soil, are the same, can not start growth during spring as soon as the latter, but may become hardier in enduring drouth and heat or less hardy, if its growth habit incapacitates it in taking full advantage of the most favorable moisture conditions of the soil. It may become hardier in countries with long and dry summers for the reason that its vital energy is not so quickly exhausted. A vine always suffers most from adverse conditions, if these affect it after it has ceased its seasonal activity.

In regard to the growth habit of different vines, I have divided the native American species into two classes, free and sluggish growers. The difference between the two is in their different scope of sensitiveness to temperature conditions of soil and atmosphere and much more in that of their roots than of their tops, or in other words, while there is little difference between the tops of free and sluggish growers in this respect, the latter have a root which is more easily affected and retarded by a low temperature than their tops. But possibly it is the other way. Sluggish growers may have about the same degree of sensitiveness in root and top. On account of the soil being colder where the roots are than right near the surface either below or above, the roots can not be as active as the tops. Free growers possibly have a root which is much less affected by the same low temperature than their tops. But the result would be the same. At least the root of sluggish growers is much more easily retarded by certain temperature conditions in the soil, than their top is by those in the atmosphere, as both generally occur at the same time.

This seems to be correct in regard to species and hybrids developed by nature in the southern States of the East, but does not hold good with all vines of a sluggish growth, selected by French experimenters, as the Berlandieri hybrids. Neither would such vines be hardy enough that they could occur wild in regions where Riparia, Rupestris and Berlandieri exist or even in intermediate regions. The great difference between root and top of sluggish growers as explained, is undoubtedly the reason why they do not grow from cuttings. The facility or difficulty with which a vine grows from cuttings, indicates therefore the extent of the difference between its root and top in regard to sensitiveness to temperature conditions.

It is probably not entirely accurate to use the two terms free and sluggish growers, as the latter in their native home have about the same growth habit as free growers have in the northern States. But in using these two terms, the effect, which is the most important in this connection, is pointed out more than the cause. The greater sensitiveness to coldness in the soil of the root of a sluggish grower in comparison with with that of its top, serves as a check to prevent it from exhausting its vitality in a region which must be extremely favorable for a rank and vigorous growth of the grape vine and so to save it from becoming a prey to parasitic organisms. On the other hand the free-growing Riparias and pure Rupestris, not easily affected by certain low temperature conditions in the soil, are enabled through this to thrive in the more northern States, where cold springs and short summers prevail. Rupestris really occurs further south, but it is enabled to succeed there, I believe, more on account of its drouth-resistant leaf and other qualities, which disappear after grafting.

In most Viniferas and the Californica we have a growth habit, quite distinct from that of Riparia and Rupestris and also Candicans and other sluggish growers, in that they start growth rather late during spring and then grow very vigorously. The reason for this is very likely, that at that time temperature conditions become extremely favorable for root and top simultaneously. Growth habit is the most variable characteristic of the grape vine, but the least variation in this respect may be productive of the greatest hardiness or the greatest weakness.

EFFECT OF GROWTH HABIT ON FORM OF ROOT SYSTEM.

The ability of a vine to make use of moisture in the soil is governed by the scope of its sensitiveness to coldness and warmth. A vine can take advantage of favorable moisture conditions only, if the soil at the same time has the proper degree of temperature, as prescribed by its scope of sensitivesess. By this we must realize what an influence the latter has on the direction the roots take especially with vines having a variable root system. But it also influences vines in this respect to some extent, which have a fixed deep or shallow root system. A Champini and considering only the scope of sensitiveness of its root, also the Lenoir would fail in a cold soil, where a Rupestris St. George with its freer root would succeed. But the Lenoir has an advantage over the other two hybrids on such a soil in having a more variable and more expansive root system and also a peculiar combination which it appears can not be reproduced again in grafting on it. The first-named two might also fail in a coarse gravelly soil even if this is warm, because their root action is too sluggish to absorb the quickly disappearing and settling moisture as well as a Rupestris St. George. Its peculiar scope of sensitiveness to temperature conditions causes the Lenoir to make both deep and horizontal main roots on the colder soils and on warm gravelly ones mostly horizontal main roots and deep laterals, almost the opposite to what Viniferas have on such soils. The form of root system of the latter for these two different kinds of soils, horizontal main roots for cold soils and deeper main roots for gravelly ones, is productive of the largest growth, but is not the hardiest. The ungrafted Lenoir has a better root system in this respect for clays and the Rupestris St. George for gravelly soils. In order that a vine with only vertical main roots should succeed well on a clay, it must be an exceedingly free grower. Although the laterals develop somewhat more, they never spread very far. Even the Rupestris St. George's root growth is not free enough to go down deeply in a stiff clay and not because its roots could not force their way down early in the spring while the ground is softened by spring moisture. Of course later in the season it would require quite a stiff and active root to penetrate through clay, while this is becoming drier.

Young Lenoir vines, if standing on a clay, should be exceedingly well cultivated in order to bring as many roots up to the

surface as possible. This will give them a somewhat freer growth after grafting, they will make deep roots anyhow on such a soil on account of the later growth of the vines. With Lenoir and all hybrids closely related to species which do not grow well from cuttings, short cuttings for propagation are the best for all close or compact soils. This is not only for reasons following from the above, but also for the reason, that a cold wet soil, packing tightly around the stem of such vines, puts this in an unhealthy condition. This seems to be the cause also of the dry rot which we see sometimes on rooted Lenoir.

ADAPTATION

The growth habit, form of root system and size of roots are principally the ruling factors in the vine's adaption, and from what has been said it may easily be deduced that the first named is the most important in this respect, as it influences the other two very much. The only difference for instance between a Berlandieri and a Cinerea, I think, is in their slightly different growth habits. But while one occurs on high ridges, the other flourishes only on the low and wet soils. Nevertheless, I don't think, that the different adaptation to soil and climate of these two species, as adaption is generally understood, alone is responsible for their occurrence under conditions so remote. I believe I shall be able to prove in the next chapter that another agency has something to do with this.

With adaptation we generally mean the ability of the vine to conform to the requirements of soil and climate. But in its wider sense it would mean also immunity from parasitic organisms, especially if these can not be successfully combated by any other means. How important adaptation is, we can see by almost all plants occurring wild. As climatic and soil conditions change sometimes within small areas, so different species and still more different varieties appear. Conditions of soil and climate are much more severe for plants occurring wild than for cultivated ones, which naturally makes the former hardier, as nature selects the hardiest, but man selects for his own special benefit and successfully overcomes the lack of hardiness in cultivated plants a good many times by other means, as substituting hardy roots in place of their own.

Viniferas, at least a good many varieties, probably have the best adaptation for California in regard to vigorous growth. But

while some of them require a warm gravelly soil to be satisfactory, others do very well on the colder soils. All vines having a more sluggish growth than Viniferas require a warmer, moister and richer soil in California. If a vine's growth is exceedingly sluggish, it does not succeed at all, because it can not avail itself of favorable moisture conditions during spring, the soil being too cold. All vines with a freer growth than Viniferas require a cooler and moister soil and a shorter growing season. This is said without consideration of form of root system; a difference in this respect might make quite a difference in adaptation. A deep-rooting, free grower would have a much better show even in a hot country than a shallow-rooting one, because in their lower strata soils are cooler and generally moister. This is probably the reason why the Rupestris St. George does so well in California, because in a proper soil all its roots are down deeply. The Rupestris St. George, Lenoir and Champinis are exceedingly well adapted to soils in California on account of their free spring growth, long seasonal activity and deep roots. The last named have less general adaptation than the first two on account of their too sluggish root growth and fixed form of deep root system, being adapted only to special soils, as exceedingly moist and warm gravelly loams.

As in California all the moisture is retained in the soil by cultivation during spring, that possibly can be held, as a case of necessity, our soils are apt to be cold during the beginning of the growing season, especially the close and compact ones. Every interspace of these is filled up with moisture and the warm air can not penetrate down readily. If soils have become somewhat dry and are then thoroughly soaked up by a warm rain, we have the greatest incentive to a vigorous and rapid plant-growth. Such conditions occur in the southeastern States.

In setting out vines on close and compact soils, these should be worked over deeply in order to make the interspaces larger, so warm air can pass down readily and the roots penetrate them without difficulty. Where such working over is not possible, exceedingly deep holes should be made and a shovel full of stable manure mixed with earth put in their bottoms, if soils are either clayey or gravelly and poor. If these are naturally rich, moist and mellow, additional manure might hurt some vines like Rupestris St. George and should be left out, but it will not easily hurt a Lenoir or Champini even on the richer soils.

GRAFTING.

As has been stated above, every variety and every hybrid has its own peculiar growth habit or peculiar combination of root and top growth habits. The lines of demarkation in this respect in regard to varieties belonging to different species or in regard to different hybrids are generally distinctly drawn, but in regard to varieties belonging to the same species are sometimes extremely fine and can not be observed by the casual observer, but nevertheless are of the greatest importance. This sometimes becomes exceedingly pronounced in grafted vines, from which we may easily get an idea as to what it means in regard to adaptation and hardiness by giving a vine a different root or a root a different top. Grafting in itself should not make any difference, but it makes a difference because we get a different combination of root and top. By substituting a different root, the vine obtained has therefore neither the adaptation of the root with its own top, nor of the top with its own root, but an entirely new adaptation.

While roots can be selected which better a vine's adaptation to a particular soil or climate, we have a good many examples in which the reverse is the case. In some instances Viniferas grafted on other Viniferas have become hardier against the Anaheim disease, in others they have succumbed more quickly. In grafting a variety on a variety of the same species the difficulty is generally not so great. The effect is much greater, either to the better or to the worse, if a variety belonging to one species is grafted on a variety belonging to another species. In grafting a Vinifera on a more sluggish grower in California there is more or less loss of vigor and productiveness. By doing the opposite, provided the new vine has a fairly good adaptation to soil and climate and there is also a good affinity and proper congeniality in regard to habit of growth, greater vigor and productiveness is the result. But considering that Viniferas have a good adaptation for California in regard to size and vigor, either by forcing their growth in giving the vine a more free-growing root (Riparia or Rupestris) or by retarding their growth with a more sluggish root (Lenoir and Champini), the result can not be always satisfactory. As has been explained, the growth habit of a vine is a most important factor. If it is too free, the vine will exhaust its vitality, before the end of the summer is reached and suffer a check in its energy; if it is too sluggish, it can not avail itself of the favorable moisture conditions

during spring. At the same time practical experience has proved, that as a rule the difference between growth habit of graft and growth habit of root, should not be too great, lest there is lack of harmony or congeniality between root and graft. A Vinifera grafted on an exceedingly sluggish grower does not succeed at all in California and if grafted on an exceedingly free grower it becomes less vigorous and productive.

As the different Vinifera varieties vary somewhat in regard to growth habit, a slightly forcing root for some would be beneficial, while with others a slightly retarding root would have a good effect, depending on conditions of soil and climate of a locality. The above remarks have been made without reference to form of root system and size of roots. A difference in this respect would also make a difference with grafted vines.

Why it is that the Lenoir with its own top on most soils appears to be an exceedingly free grower, while after being grafted to Vinifera, it retards the latter's growth, would be difficult to explain and more difficult to understand. But, I believe, an understanding of it would be helped, by comparing it to tones in music. While some of these quite a distance apart on the scale, sound well together, others much closer to one another, make a discord. Although there is quite a difference in regard to sensitiveness to temperature conditions between the root and top of a Lenoir, their congeniality is perfect. A similar relationship of root exists probably with some Viniferas, only less pronounced. To embrace all the different conditions of relationship between stock and graft in the word affinity, is extremely inadequate and inaccurate. For instance a Berlandieri, grafted on a Vinifera grows vigorously, but reverse it and it is a failure. The affinity in grafting certainly is the same in both cases, but while a Vinifera root has a good congeniality in growth habit to a Berlandieri top, vice versa congeniality is entirely lacking.

It is well known from European viticultural practice, that the quality of the grape is much influenced by conditions of soil and climate. The Riesling produces its most valuable product along the Rhine, it is worthless in Spain or Italy. The Grenache and Mataro have value only in southern France or northern Spain. Grafting a Vinifera on a more free-growing root is the same as transplanting the vine on its own root into a warmer climate or soil. Grafting on a retarding root is the same as transplanting the vine on its own root into a cooler climate or soil.

While in some cases the quality of the fruit is improved through grafting, in others it becomes inferior. This is said without regard to form of root system. A difference in this respect would make the effect either more or less pronounced. In grafting, the character of the vine is changed and in consequence also the character of the fruit.

It is generally considered that the root system of vines and trees is commensurate of the size of their tops. This undoubtedly holds good with most ungrafted trees and vines, but not always is correct with grafted ones. In grafting on a more freely growing root, the size of the root system may be much less in dimensions than the top growth, but such a diminutive free root is perfectly able to supply the larger top with nourishment, as long as moisture is within reach. But this will become exhausted from such a small space much sooner than from the large space covered by a vine with a more expansive root system. Such a condition exists with vines grafted on Rupestris St. George standing on stiff clays.

RESISTANCE TO THE PHYLLOXERA.

In regard to resistance to the Phylloxera it must be remembered, that the vine's ability to overcome the effect of the work of the insect, does not depend only on its innate resistance, but is much influenced also by adaptation and hardiness to other diseases and with grafted vines also by affinity and congeniality. Aestivalis, Candicans and Labrusca with a somewhat low resistance thrive well in their respective localities. Their resistance is entirely sufficient or nature would have developed a higher one, if it was necessary. In fact Mr. T. V. Munson, of Denison, Texas, considers the Candicans the hardiest American vine capable of enduring the greatest drouth and heat. If this was unconditionally correct, why does it not occur also in Georgia or Florida, where climatic conditions for a large and vigorous growth of the grape vine are certainly much more favorable than in Texas. Birds carry grape seeds in all directions. On the other hand Cordifolia and Rotundifolia with the highest resistance possible, certainly must need this, or nature would not have developed it, as it does not develop any qualities which are unnecessary for the maintenance and survival of its products.

CHAPTER II.

THE CALIFORNIA VINE OR ANAHEIM DISEASE.

It is generally admitted that the disease is caused by a minute living parasitic organism and is therefore contagious. But as long as the organism is not found, an exact idea in regard to its nature and manner of attack on the grape vine can not be formed. It is only from its visible effect on the vine, the ensuing consequences and other signs and symptoms, that we can draw our conclusions. My observations during the last few years have led me to be convinced that two kinds of infections may occur, through the root and through parts of the foliage, and that the disease may appear in five different forms or manners in which it affects the vine.

Form I, the latent or incipient form. I am not entirely convinced that it is proper and accurate to call this form latent. It may be simply the first imperceptible attack on the root of the vine by the disease, having so little consequence, that the vine does not show any of its effect. But I am convinced that in some cases Viniferas on their own roots in the Santa Cruz Mountains, having obtained full size before the disease germs entered the tissue of their wood and on favorable soil, may have this form for ten years and show perfect health and thriftiness.

Form II. As soon as the vine is exposed to adverse conditions of one kind or another, weakening its vitality, Form I developes more or less rapidly into the more acute Form II. This form in its beginning causes the vine sometimes to bear a heavier crop as the first symptom of diminishing vigor. The heavier crop in turn weakens the vine and favors the further development of the disease. Form II generally shows itself in an unthrifty growth of the vine, the latter setting a heavier crop than it can develop properly, the grapes apparently mature, but are low in sugar. The vines sometimes fail to make growth from some spurs or only short growth. Some which seemingly have made healthy growth, occasionally die all at once during the latter part of the summer or the following spring.

It appears that in this form the disease germs do not enter the top of the vine, the latter probably dies from want of nourishment, without showing any of the characteristic spots on the leaves or showing only very indistinct ones late in the season. Young vines which had the disease as Form I from the time they were

planted, generally succumb with Form II, if not perfectly hardy. Some Viniferas develop this form more rapidly on the moister soils, which favor a rank growth (Tokay), others on the poorer and drier soils, on which the growth becomes impoverished.

Form III. In this form the disease enters the top of the vine from the root, which almost always seems to occur while the growth of the vine is rapid and exposed to great heat and a dry atmosphere and transpiration through the foliage therefore excessive. Vines which are not exceedingly vigorous, may also show this form, but such vines always attained their full size before the disease entered the tissue of their wood, which enabled them to go through Form II without being killed. In grafting Lenoir, Cordifolia, Candicans and others, which have been considered resistants unconditionally, on Riparia, having the disease as Form I, and irrigating heavily, so vines make rapid growth, while the heat is great, the grafts will readily develop Form III of the disease. Similar cases can be seen also in the field sometimes; vines having shown great vigor, rapidly develop Form III from Form I. The characteristic symptoms of Form III have so often been described as the only symptoms of the disease, as immature wood on the canes, especially the tips, short growth, failure of fruit to mature and spots on the leaves, that it is not necessary to dwell on this point. Rupestris St. George vines favor an acute development of the disease more on the richer or moister soils and Lenoir and Champini vines more on the poorer or drier. The above three forms are simply different stages in the development of the disease and lines of demarkation are not always plain. Whenever the disease makes its presence known as Form III, we may be sure, that most of the vines in the vineyard, however thrifty they may be, have the disease as Form I, and a good many as Form II. As I have recommended topping vines as a preventive of the disease, I must say at the present time, that, while it seems to prevent Form III somewhat, it apparently increases the chances of the disease as Form II. But if practiced lightly in checking the growth of running canes by pinching, I believe it has a good effect.

I have never seen an American vine on its own root in this locality show Form III of the disease, but at its worst only the beginning of Form II, which manifests itself with these vines in a slight unthriftiness and by no other signs. Whenever a vine shows unthriftiness, we must conclude, that this disease, if not the

main cause, is at least an auxiliary cause, because as soon as the vine is affected by adverse conditions, the disease also becomes more active. But an American vine, ungrafted, (Rupestris St. George, Lenoir, Champini and a few others) will recover from Form II, if placed under more favorable conditions. A Viniferagrafted, hardy American vine may also recover after the top has died, even if the latter should show Form III. I have a few Rupestris St. George vines on the place as examples of this latter possibility, which are exceedingly vigorous and healthy at the present time. The extremely heavy bearing of a vine, induced by too long pruning and exceptionally long dry summers are probably the most fruitful causes for the development of the disease into an acute stage.

There are two other forms of the disease, in both of which infection seems to take place through parts of the vine above ground, the bloom and some other portion of the foliage. These two forms do not occur much and apparently affect only vines, which have become considerably weakened by the root Form II. They seem to occur mostly in such places, where on account of the nature of the climatic conditions or the nature of the grafting stock the stage of the disease as Form II is much prolonged.

My observations regarding the Anaheim disease have been made in the Santa Cruz Mountains and if they should not correspond with the behavior of the vines, attacked by it in other places, allowance must be made on account of the probable difference in the climatic conditions.

THE ANAHEIM DISEASE A NATIVE OF THE EASTERN STATES.

It appears to me that the organism, causing the California vine or Anaheim disease, must be a native of the eastern States, but existing mostly as Form I, and the disease occurring occasionally as Form II and causing the death of vines. Although the evidence, which I can bring in support of this claim, is all circumstantial, I consider it exceedingly strong and after giving two reasons, which have led me to think so, shall proceed from the supposition that it is correct.

In the first place the manner in which American vines as well as Viniferas die in the eastern States, reminds one very much of the death of vines by Form II of the Anaheim disease in California. Mr. T. V. Munson, to whom I am much indebted for in-

formation concerning the behavior of native vines in the eastern States, informs me that Riparia, Rupestris and Solonis, grafted and ungrafted, on upland sandy soils in eastern Texas are short-lived. They generally succumb after a season of a severe drouth by what has been called root-rot by some. Why should this be so? Our California experience, before we had this disease, has taught us that these vines on such soils and under drouth conditions much more severe than any occurring in the eastern States were quite thrifty and long-lived, at least ungrafted most anywhere. Considering our greater heat during the summer, drier atmosphere and in consequence the more rapid transpiration through the foliage of vines, this would be a singular phenomenon. On Mr. Munson's nursery grounds Riparia Gloire de Montpelier and Rupestris St. George are less vigorous than Solonis, Doaniana and other native vines. This also is contrary to our experience. What a difference for instance is presented by ungrafted Riparia and Rupestric vines in the Santa Clara Valley and such vines in the Santa Cruz Mountains! While in the former they die off sometimes quite suddenly after a few years' growth, in the latter this seldom occurs and it is only the unthrifty growth of a vine here and there which leads one to suspect as cause, either direct or indirect, the disease. How much greater should be the difference between any part of California and any of the eastern States where the heat is less intense and the atmosphere less dry, in regard to the visible signs of the disease.

In the second place the distribution of the native American species over the eastern States can not be explained by adaptation alone, accepting the word adaptation here in its narrow sense, as it is generally understood. Wy should not the free-growing Riparia and Rupestris flourish much better in Florida and Georgia or adjoining States on sandy or gravelly creek beds than in those regions, where they do occur and where climatic conditions for a vigorous and rapid growth of the grape vine are much less favorable, if it was not for the fact that conditions for the developmnet of the disease are also much more favorable in the former States. The distribution of grape seeds through birds is unlimited, wherever there is land connection. Riparia and Labrusca are natives of eastern States, where heavy frosts occur. Considering their great hardiness to frost and the shallowness of their roots, it is not unlikely that this assists them in fighting their battle for

existence with the disease. According to Mr. Munson the Berlandieri occurs mostly on the upper portions of limestone ridges, but occasionally descends down into the bottoms of ravines and creeks. Why is it not more numerous on the richer soils than on the poorer and drier? From our experience, before we had this disease, we know, that most any vine will succeed much better on rich or moist soils than on the poorer or drier. Wherever a wild vine is found most, there conditions for its best development are most favorable. Why does the Berlandieri not inhabit Georgia or Florida, where summer rains are much more frequent and regular than in western Texas? In the distribution of native vines over the eastern States we find that almost every region and every kind of soil has its own species of grape vine, or if more, related species. We certainly have the same phenomenon also with other annual and perennial plants. A good many species of wild plants have their own restricted area, where they succeed well, while in other places they are unthrifty and short-lived. But how do we know, that in such unfavorable locations the death of such plants is not hastened or caused directly by some minute organisms, which have defied discovery by the closest microscopical investigations?

ORIGIN AND DEVELOPMENT OF AMERICAN SPECIES.

I believe it is claimed that all existing grape species have descended from an original or primordial form different from any existing species. But this primordial form undoubtedly has been much more like the Viniferas than any of the American species, as the former are least hardy to any of the parasitic diseases of the grape vine and also least hardy to extremes in climate. Nature always developes the hardiest and it is not very likely that it would make a retrograde movement in producing the Eupopean species, at least not in regard to enduring extreme cold conditions, as in the northern countries of Europe, where the Viniferas can not exist, climatic conditions are not any more severe than in the northeastern United States or southern Canada. If the original species had possessed any resistance to the Phylloxera, some traces would be left of this in Vinifera, taken into account its manifold types. In regard to resistance to the Anaheim disease—this is a matter of adaptation. Considering the fixedness of the forms of American species and their peculiar distributions for special soils and over restricted areas, a good

many forms of the original species must have succumbed and only the hardier ones, possessing a perfect adaptation to the soil on which they stood and its climatic conditions remained. As the Anaheim disease organism became gradually more effective in its work the different specific forms also perfected themselves and became more fixed and more uniform in their varietal types for the different soils and climates.

The Vinifera species during this time, not being subjected to such in influence, did not change much; it did not develop into more specific forms, although acquiring a good many varieties, but which must be ascribed principally to the agency of man.

The difference between Vinifera and the American species is not as great as one might suppose at first thought. The great variety of growth habits and combinations Vinifera presents in its different forms, although all in a slighter degree than with the different American species, leads one almost to suspect that all of the latter have descended from the former. In this case we would have to look at different Vinifera varieties as the incipient forms of American species. (See "Origin of Species" by Charles Darwin.)

Let us see now what special changes the grape vine underwent in order to cope successfully with the Anaheim disease and the severer climatic and special soil conditions. It has been mentioned that the two principal species in the northern States, Riparia and Labrusca, are exceedingly hardy to frost and shallow-rooting and that the former, occurring more in the middle-west, is extremely free-growing or is little affected in its growth by coldness in the soil. In the southern States almost all species are sluggish growers, more or less, which is indicated by the absence of the rooting quality of their cuttings, besides they are mostly deep-rooting. In the Rotundifolia we probably have the greatest divergence from the original type, having lost all affinity in grafting to other species and being entirely uniform in its varieties. It occurs in a region where conditions for a rapid and rank growth of the grape vine must be extremely favorable and therefore also favorable for the development of the Anaheim disease. But it could not inhabit the region or the soil where the wild Rupestris is found mostly; its too sluggish root-growth would incapaciate it in the presence of the disease to draw sustenance from a coarse, gravelly soil, in which the moisture settles down rapidly. The Rupestris is a species of late development; its somewhat less uni-

form type proves this. It has probably originated through the blending of Riparia with one or more southern species, possibly the Monticola and Cordifolia, but taking after the first-named entirely in growth habit. By a peculiar combination of the qualities of its parents it is enabled, although an exceedingly free grower, to exist in a hot country. We know from our California experience. that such deep and poor gravelly soils with perpetual moisture in their lower strata, on which it is found wild, are not exceedingly favorable for the Anaheim diseases.

It must strike us as peculiar that there are no intermediate forms in regard to growth habit, excepting possibly some scattered individual vines here and there, between Riparia and Labrusca on one side and species occurring in the southern States (sluggish growers) on the other side. Vinifera has the intermediate forms. but these could not occur in intermediate regions on account of the Phylloxera, Anaheim and other diseases. The phenomenon is easily explainable by the climatic conditions of the East. The change from the frost belt to the almost frostless belt is very abrupt.

All American species, excepting the Californica and possibly the Arizonica have developed by natural selection under the influence of the Anaheim disease in their respective areas and soils. They are threfore all, with the one expection, perfectly hardy against it in their own locality, but generally not perfectly hardy anywhere else. The Californica very likely has descended from a species highly resistant to the Phylloxera, but as it came to California and attained its present character, before the insect found its way here through the agency of man, most of its resistance has been lost. Resistance to the Phylloxera is not an original or generic quality wth the grape vine. If it was, all vines would have about the same resistance. A vine can not develop any of it without the actual presence of the insect on its roots, but it may be there by inheritance.

The Californica, with one other possible one, Labrusca, comes nearer having about the average growth habit of the Vinifras, than any other American species. After having been absent in numerous transitional forms, the original growth habit of the grape vine appears again, as the Californica developed with only climate and soil exerting their influence and without the influence of the Anaheim disease. It is not probable, that it has descended directly from the Labrusca, as this species could not overleap the

barrier of the middle-west without diverging into other forms first. The Californica is very likely a direct descendant of Candicans. Although these two species resemble one another very much in general aspect, what a variation the former presents from the latter in growth habit. While with the Candicans the difference between root and top in this respect is exceedingly great, in the Californica we have almost the same scope of sensitiveness of root and top to temperature conditions.

HARDINESS OR RESISTANCE AGAINST THE ANAHEIM DISEASE.

There is no innate resistance against the Anaheim disease in any grape species, as we have it in the resistance to the Phylloxera. A perfect adaptation is resistance, an adaptation, which produces the healthiest growth, neither a rank growth nor an impoverished growth. Through proper manipulation, as described above, the disease can be caused to enter the wood of a Lenoir or Candicans as readily as that of a Vinifera. Lack of adaptation is not the prime cause of the disease, but it causes the disease to become fatal to the grape vine. In the ungrafted Rupestris St. George, Lenoir and Champini we have examples of what is needed in California, as far as hardiness to the disease is concerned. They are hybrids between free and sluggish growers. We need such a combination with more or less of the essential qualities of each class, in order to enable the vine to take advantage of the spring moisture in the soil, while this is cold and also to enable it to go unscathed through our long dry summers. The size, vigor and hardiness of a vine are the result of energy taken up and assimilated, while conditions are favorable, minus the set-back it receives during the season through some cause or other. If this latter is too great during the summer for the vine to withstand or to overcome the following spring, it becomes a failure sooner or later. A vine which makes slow growth in the beginning, but never receives any check to its progress, may soon outstrip a vine of quick free growth, but which suffers at times from adverse conditions. Living organisms are as a rule not adapted to extremes. Those which endure wet conditions, can not endure dry conditions and vice versa. Standing in an exceeingly moist soil during spring, causes some species to make rank and soft growth, which is apt to become unhealthy during the heat and dryness of summer and so creates favorable

conditions for the development of the disease. Vines, especially those with a variable root-system, will become accustomed to soils holding somewhat excessive moisture, if this is uniformly so during the same season and one season after another, or to soils holding scant moisture if it is the same continually. The moisture conditions can be made more uniform by proper and intelligent cultivation and by giving the vines ample space. This latter saves money, labor and trouble.

Wherever the disease has made its appearance, it is sometimes difficult to start young vines. On account of the disease germs entering the tissue of their wood, as soon as they begin to grow and their roots not being down deep, where the soil remains moist and cool, they are apt to suffer somewhat even on rich ground and the disease soon developes. It is simply a question whether the disease shall remain as the harmless Form I or develope into the deadly Forms II and III. For this reason young vines should receive careful and intelligent treatment in cultivating the ground thoroughly, holding an abundant and uniform moisture supply from the time they are planted. On coarse gravelly soils or any soils, which are apt to become dry or heated near the surface, it is well to give them some irrigation for the first and second year in order to enable them to go through the summer in the best condition. A gallon of water, applied in two doses during June and July will help them along wonderfully. Because a certain resistant has not been a success on a particular soil, does in a good many instances not prove that it would not have succeeded, if it had received proper treatment. Slipshod methods in grape culture will not do, wherever the Anaheim disease is present.

Even where the Phylloxera has not made its appearance, but the Anaheim disease has, it is extremely unwise to plant Viniferas on their own roots, as for most any soil we have grafting stocks at present, which will cause them to do much better and last much longer than they will on their own roots. But considering the great uniformity of all the varieties of any of the American species we must realize how necessary it is that we get a certain type of vine for a particular soil or locality in selecting not only the proper root but also the proper graft. To choose the proper root is most important and to choose a proper graft is almost equally important, because the tops of no two vines grow exactly alike. But it is impossible to lay down exact rules for guidance in either of the above requirements, because conditions of soil and

even of climate vary in California as well as in any country with summer rains. It is for every vineyard owner himself to find out, which is best for his special conditions.

Of the resistants on hand at present the Rupestris St. George is probably the one which has the greatest usefulness, at least for the Coast mountain region, the only one, with which I have acquaintance. With the proper graft it seems to hold out well on a good many kinds of soils, especially deep gravelly ones, excepting those exceedingly rich or moist, where its growth is too rank, while the vine is healthy. Although it resists well against the disease on clays, it is not a good success on such soils for other reasons, as lack of vigor and inferior quality of fruit; but with a favorable graft it will even do fairly well on clays, if these are not overly stiff. Whenever a resistant stock has not a perfect adaptation to a soil or climate, extreme care must be taken in the selection of the graft; if the adaptation is perfect, then this is not quite so essential. The Rupestris St. George has a misleading name. It undoubtedly belongs to the Champini group of vines, which are hybrids between Candicans, Monticola and Rupestris, but not always showing their relation to each of these species. While the other Champinis take considerably in their growth habit after their sluggish-growing parents, the Rupestris St. George has its growth habit almost entirely from Rupestris, but with a much longer seasonal activity and with the form of root system and the fleshy roots of the Champinis, as developed by nature.

With Riparia-Rupestris 3,306 I have but little acquaintance, but if it is a hybrid between Riparia and Rupestris St. George, it would explain its resistance to root-rot in France. Although the Rupestris St. George has not this quality, some of its parents have. If the origin of Riparia-Rupestris 3,306 is as stated, it will give this vine very likely value for the richer or moister soils, on which the Rupestris St. George succumbs. The two mentioned stocks are supposed to be perfect resistants against the Phylloxera, although this would depend also on other conditions, as explained above.

Of stocks which are more sluggish growers than the Viniferas, we have the Lenoir and Champinis. The former ungrafted is the hardiest and healthiest vine for California for all soils from medium to rich. It has some value as a direct bearer, as it produces fairly good crops, its grapes containing a good deal of coloring matter, useful in the making of red wines. As a grafting

stock it has its best value for soils exceedingly rich and deep, especially those somewhat close and compact, but which warm up readily, as rich sandy and gravelly loams. It does well also on somewhat cold clays, if the vines are not set down too deeply. The butt end of a Lenoir or Champini cutting should not be more than 8 or 10 inches below the surface, more or less deep according to the nature of the soil.

The Champinis have a more restricted adaptation than either the Lenoir or Rupestris St. George. Their best adaptation seems to be for rich gravelly loams, holding an abundance of moisture. The Barnes and De Grasset apparently are the hardiest of this group. The latter will grow on a soil less rich but not less moist in its lower strata. The Barnes is the most vigorous of the Champinis and will also do fairly well on clays.

The Lenoir and the Champinis have a resistance of 12 and 14 to the Phylloxera, which is generally not considered high enough for grafting stocks. But what has been said above, that grafting in itself does not weaken a vine, must be recalled here also. It depends to a large extent on the soil, climate and graft, what resistant will hold out the longest, whether the resistance is 12, 14 or 16. But it seems to be an established fact, that there is a much greater choice of soils and grafts for the Rupestris St. George than for the Lenoir and Champini, where both the Anaheim disease and the Phylloxera have to be considered. The trouble with Rupestris St. George, Lenoir and Champini is, that they are extremes in regard to growth habit for California conditions. For this reason great care must be taken in choosing the proper soil and graft for them. The Lenoir root stands between the other two, but much closer to Champini than Rupestris St. George. It would require a dozen hybrids or more, every one of them with a root of a different growth habit to fill the space between the Lenoir and Rupestris St. George.

In regard to grafts it appears, that in a good many cases new varieties will take the place of old standard varieties. Our experience which we have made with vines on their own roots must be almost entirely disregarded, because it is apt to mislead us. Varieties which succumb readily to the Anaheim disease on their own roots, may hold out much longer, if grafted on resistants, than varieties which have proved hardy ungrafted. But with the Lenoir as a grafting stock the latter kind are undoubtedly the best, because we have a similar combination of root and top growths of such vines grafted on this stock and ungrafted.

According to Prof. Newton B. Pierce, the Tokay, Grenache and Malaga are hardiest on the Lenoir. With Mr. Wm Pfeffer of Cupertino the Tannat and Petite Sirah have held out longest on Champini of those Viniferas, which he has had under cultivation. With Rupestris St. George and other free-growing stocks I find that such Viniferas, which do not do well on account of lack of heat in soil and atmosphere, as the Emperor and Petite Sirah with me, are the best success, not considering other requirements. The choice of grafts would have to vary some according to special conditions of climate and soil. To almost every vineyard owner the problem presents itself, to find for a given soil the right resistant and for the latter the right graft. As a rule free-growers with a deep vertical root-system, similar to Rupestris St. George, for gravelly soils from medium to poor, and stocks of a somewhat sluggish growth, similar to Lenoir, with both deep and horizontal main roots, for the close and compact soils will give the best results; but there will be exceptions. We do not want to think that there are many 5-acre tracts, especially in mountain regions, where the same stock, or if the same stock, the same graft will give the best results.

From what has been said on the origin and development of American species in the southern States of the East, it must not be supposed that we need similar vines, or rather vines similar to Lenoir, for our richer soils. Cultivation alters, and intelligent cultivation improves conditions very much for the grape vine against the disease. Young vines, on which the disease is most severe, might not be able to get started at all on wild land in the East with regular summer rains and might do well in California on cultivated ground and live a long life.. Cultivation should be so that extremes in the moisture contents of a soil are avoided during the season and one season after another. Deep gravelly soils on hillsides in the Coast mountain region hold the most constant moisture in their lower strata for a deep-rooting vine.

In the study of soils in regard to adaptation the moisture conditions are of the greatest importance. These do not depend on the physical structure alone but also on climate and cultivation. The first-named does not mean only the mineral ingredients of a soil, but includes also the humus contained in it, which latter has the greatest influence on the soil's capacity for holding and retaining moisture. There are principally three kinds of soils in regard to moisture conditions, the coarse gravelly ones, in which the moisture settles down by gravity, the close and compact, in

which it rises to the surface and those half-ways between these two, in which it is held well in suspension. In regard to temperature conditions, dark colored soils warm up more readily than light colored ones, and gravelly soils more readily than compact ones, so gravelly or sandy loams, rich with humus, are the most favorable for both conditions and produce the rankest growth. In California not only the surface soil requires consideration, but the sub-soil is of prime importance, as all vines must make deep roots, in order to be enduring of drouth and heat and so of disease.

While I think that, wherever the Anaheim disease is present, the hardiest vines and in the quickest manner are obtained by planting resistants in the field and by postponing the grafting till the vines are nearly full size, cutting-grafting or grafting very young vines in the field has to be resorted to, if the stocks do not graft well when of full size. Besides with the disease germs in the tissue of their wood, it is extremely difficult to graft some resistants in the field, especially if the grafting is done late in the spring, because the disease developes, while the vines are without foliage and so causes a good many failures or kills vines right out. But Lenoir and Champini should always be left ungrafted till they are nearly full-sized, excepting possibly on soils which are extremely rich, moist and warm, as rich sandy or gravelly loams.

The greatest care must be taken in the selection of healthy grafting wood for scions, as the disease works as a degeneration. It is probably the same as what we call this with other plants. Cuttings, to be used as scions, should be taken only from vigorous but not rank-growing vines. It is safest to take the cuttings from vines, grafted on hardy stocks with which the rules, as explained above, have been complied with. Resistant cuttings intended for propagating purposes require the same consideration. It is generally best to take these from vines on their own roots, standing on the proper soil or any soil on which they make healthy, vigorous growth. Rooted stocks, which are always preferable to cuttings for planting, should be strong and healthy and it is best to discard all weak and feeble ones.

As has been stated, the difference between the tops of different species in regard to growth habit is not nearly as great as the difference between different roots. In fact the Vinifera species offers about as much of a variety of top-growths as the whole of the American species. It will therefore be just as easy

to find hardy stocks for varieties of the former as for hybrids between Vinifera and so-called Anaheim-disease-resistant vines, as long as grafting has to be done.

The difficulty in hybridization is, that, although resistance to the Phylloxera, growth habit, form of root-system and size of roots are variable qualities with the grape vine, these have become so firmly established in their respective degrees and tied to one another with the different American species through selection by nature under the combined influence of the Anaheim disease, Phylloxera and climatic and soil conditions of the particular locality where each occurs, that they have become extremely fixed and persistent. As the work of French experimenters has proven, it is extremely difficult to separate them and combine again, each in the proper degree. If one quality changes, the other qualities change correspondingly. Still we have enough examples on hand to convince us that this can be done. As long as we have not found a way of giving medicine to the grape vine internally with good effect, prevention of the disease will be possible only in the manner as has been the object of the writer to explain in the above treatise.

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