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cient in exterminating the "pest" or disease in the French vineyards if properly applied and strictly carried out; and if the vines have a fair amount of vitality left when operated on, they will thrive well afterwards and bear good crops for an indefinite number of years.

VIII. Notes on "Clover-sickness."

By J. H. Gilbert, Ph.D., F.R.S., F.C.S.

Having been informed by Mr. Berkeley that it was his intention to make some observations on the subject of "Clover-sickness" at the Meeting of the Scientific Committee to day, and having been requested by him to state briefly the results of the attempts made at Rothamsted to grow clover more frequently on the same land than custom recognizes as practicable, I have, in conjunction with Mr. Lawes, drawn up a summary statement of the plan and results of the experiments, partly in the form of a short abstract of previously published accounts, but bringing the record up to the present date.

Among the causes which have been assigned for clover-sickness may be mentioned:—

Exhaustion of the soil.

The growth of parasitic plants which strike their roots into the clover and exhaust its juices.

Destruction by insects.

The injurious influences arising from the matter excreted by the roots of a former crop, or from the decay of the roots themselves.

The growth of the young plant under the shade of a corn-crop.

With regard to the last supposition, which, in a letter in the 'Gardener's Chronicle' of May 13th, Mr. Berkeley seems disposed to adopt, it may be stated that during the period of twenty-three seasons over which our experiments on the subject have now extended, clover has more frequently been sown alone than with a corn-crop, and the failures have been as signal under those as under the usual conditions.

The experiments on the growth of clover with many different descriptions of manure were commenced in 1849, and, with the occasional interposition of a corn-crop or fallow, have been continued up to the present time. The land is divided into three main divisions, each of which comprises a series of six plots.

Series 1.—The plots of this series have received no carbonaceous, and scarcely any nitrogenous manure since the commencement. On the other hand, some of them have received much more of both potass and sulphuric acid, and more phosphoric acid, but all less, and generally considerably less, lime and magnesia than have up to this date been taken off in the crops.

Series 2.—These plots have all received a considerable amount of both carbonaceous and nitrogenous manures, supplying, on the average, about half, but in some cases more than half, as much of both carbon and nitrogen as have been taken off in the crops. Of potass and sulphuric acid, some of the plots have received considerably more, of phosphoric acid rather more or not much less, of lime very much more, but of magnesia in all cases less than were yielded in the crops.

Series 3.—The plots of this series have also received a considerable quantity of both carbon and nitrogen, but all of them less than those of series 2. Some of them have received more, or not much less, potass, magnesia, and phosphoric acid, considerably more sulphuric acid, and very much more lime than were contained in the crops.

These very summary comparative statements relate to the whole period from 1849 up to the present time ; and the observations which follow will for the most part have reference to the same period. But it should be observed that many of the plots which now show an excess of removal over supply of certain constituents did not do so at the time of the first failures. It will presently be seen that failure commenced after growing the crop a second time with the interposition of only a single wheat-crop. This was the case notwithstanding that at that time, and even later, on some of the plots more of all constituents (excepting perhaps carbon) had been supplied in manure than taken off in the crops. It was obviously, therefore, not merely a question of supply or exhaustion, using the terms in the same sense as we should do in reference to wheat or barley, for example. One object of the plan of experimenting followed was, therefore, to give time for the proper *soil-digestion*, or distribution of the constituents already directly supplied, or which might otherwise exist within the soil, in case this might be the condition needed.

As with other *leguminous* crops, the general result has been that mineral constituents applied as manures (particularly potass) considerably increased the early crops; whereas ammonia-salts had little or no beneficial effect, and were sometimes injurious. It may be added that even up to the present time the beneficial effects of long previous applications of potass are apparent whenever there is any growth at all.

To go into a little more detail: The crops were throughout very heavy in the first year (1849), especially on the plots of series 1, with mineral, but with no carbonaceous or nitrogenous manure. In the autumn of that year wheat was sown, and in the spring of 1850 Red Clover. In 1851 small cuttings were taken; and in 1852, though the crops were not heavy, there was by no means a failure. Since that time, however, all attempts to grow clover year after year on the same land have failed to give anything like a full crop, or a plant which would stand the usual time on the ground. Small cuttings were obtained in the autumns of 1855 and 1859 from seed sown in the spring of those years, and small cuttings, but rather heavier than in the former cases, in 1865 (June and August) from seed sown in 1864.

On the plots of series 1, seed has been sown ten times during the twenty-three years of the experiment, namely, in 1848, 1850, 1853, 1854, 1855, 1859, 1864, 1868, 1869, and 1870. In seven out of the last eight trials the plant has died off in the winter or spring succeeding the sowing the seed; and at the present time the land is again ploughed up, the plant having entirely died off in the spring, now three years in succession. The plots of series 2 and 3, on the other hand, though previously sown as frequently as those of series 1, were not sown in either 1868 or 1869, but were ploughed and left fallow, and only sown again in 1870; and they carry, at the present time, a rather thin, but fairly healthy crop; whilst, as already said, the plants from the seed sown at the same time on series 1 entirely died away in the spring.

The difference between the conditions of the plots of series 1, resulting at the present time in entire failure, and those of series 2 and 3, affording at least comparative success, may be briefly summarized as follows:—

In the first place, in the cases of the utter failure, seed was sown, and plants came up, in 1868 and 1869, as well as in 1870, that is in three consecutive seasons; whereas in those of the partial success none was sown between 1864 and 1870.

So far as regards manure, the chief distinctions are—that where there is entire failure, neither carbon nor nitrogen has been supplied in manure; but where there is partial success both have been supplied, but neither of them in amount equal to that of their removal in the crops. With regard to mineral constituents, the conditions of series 1, resulting in failure, are—a considerable excess of supply of both potass and sulphuric acid, and a considerably greater excess of both than on either series 2, or series 3; no essential difference as to phosphoric acid; a greater deficiency of magnesia than in either series 2 or series 3; and lastly, a considerable loss of lime, whereas on the plots of series 2 and 3, very much more lime has been supplied in manure than taken off in the crops.

It would appear, therefore, that if the failure on series 1, compared with series 2 and 3, be due to the greater exhaustion of certain constituents, it must be of either carbon, nitrogen, magnesia, or lime. On this point it may be mentioned that the excess of carbon removed in the crops, over that supplied in the manure, has been in no case nearly approaching that which may take place with impunity in the case of either wheat or barley. On the other hand, the average annual removal of nitrogen has been considerably greater on all the plots of series 1, but generally less on those of series 2 and 3, than happens with either wheat or barley grown without nitrogenous manure; it has, however, been considerably less than in experiments on the mixed herbage of grass-land where no nitrogenous manure has been employed.

Again, taking of course the whole period, the exhaustion of magnesia has been generally greater, and that of lime considerably greater, than has occurred in the experiments on the continuous growth of wheat or barley. So far, then, as the result depends on mere amount, rather than on condition or distribution of constituents, it would appear to be connected with a deficiency of nitrogen, of magnesia, or of lime, or of more than one of them.

Having regard to the question of the condition and distribution of the constituents, in 1864 a portion of the land of series 1 was trenched 2 feet deep, one third of the manure being mixed with the layer from 24 to 16 inches, one third from 16 to 8 inches, and the remainder from 8 inches upwards. Superphosphate of lime, and salts of potass, soda and magnesia, the first two in very large quantity, were used; and nitrate of soda, which is a much more favourable form of application of nitrogen for leguminous crops than ammonia-salts, and which distributes more rapidly, was also liberally applied. Owing to the character of the season, the mechanical condition of the land was very unfavourable after this treatment; and, although many years have now elapsed, and the excess of constituents supplied is in some cases considerable, the plant has died off as completely on the plots so treated as elsewhere.

In view of these failures in the field, it is a fact of much interest that in 1854 Red Clover was sown in a garden only a few hundred yards distant from the experimental field, on soil which has been under ordinary garden-cultivation for probably two or three centuries, and it has every year since shown very luxuriant growth; and after resowing four times, namely, in 1860, 1865, 1868, and 1870, during that period, there is at the present time not only no indication of failure, but, on the contrary, very luxuriant growth. It may be added, by way of illustration merely, that if the produce on these small garden plots be calculated to the acre, it would represent a removal in seventeen years, at the rate of more than 1½ ton of lime, nearly ½ ton of magnesia, more than a ton of potass, nearly ½ ton of phosphoric acid, and about 1½ ton of nitrogen per acre, without the supply of any of either during the period of the experiment.

Lastly, in the winter of 1867–68, small portions of the land of series 1 were dug, some to the depth of 9 inches, some to the depth of 18, some to the depth of 27, and some to the depth of 36 inches, and sown to the respective depths with different manurial mixtures; supplying in some cases very large amounts of potass, soda, lime, magnesia, phosphoric acid, sulphuric acid, nitrate of soda, &c. From other similarly sized plots, the soil was removed to the depth of 9, 18, and 27 inches respectively, and replaced by soil from the same depths from the garden border, on a portion of which clover had been grown successfully since 1854, as above referred to. In April 1868, clover was sown over the whole of these small plots, as well as over the rest of the land of series 1 not so treated; but the plant for the most part died off during the winter. The same portions were resown in April 1869, and small quantities of clover were cut in September of that year; but the plant again died off in the winter. In April 1870, clover was again sown, this time in conjunction with barley; but the plant again died off during the past winter and early spring. This result should not, however, at present be taken as absolute proof of failure of the manurial conditions supplied on the various small plots; for not only was the summer of 1870 one of extraordinary drought, but where the manures were applied at the different depths specified, the land may not yet have recovered a favourable mechanical condition, and where the natural soil was replaced by that from the garden border, the plants, being luxuriant compared with any around them, were more a prey to woodpigeons, rabbits, and game. The whole of these small plots are now resown, and those of the garden-soil are entirely enclosed, both around and above, by galvanized wire netting.

The general result of the experiments in the field is—that neither organic matter rich in carbon as well as other constituents, nor ammonia-salts, nor nitrate of soda, nor mineral constituents, nor a complex mixture, supplied as manure, whether at the surface or at a considerable depth, has hitherto availed to restore the clover-yielding capabilities of the land.

On the other hand, it is clear that the garden-soil supplied the conditions under which clover can be grown year after year on the same ground for many years in succession.

The results obtained on the garden-soil seem to show that what is called "clover-sickness" cannot be due to the injurious influence of excreted matters upon the immediately succeeding crop.

That the clover crop frequently fails coincidently with injury from parasitic plants, or insects, cannot be disputed; but it may be doubted whether such injury should be reckoned as the cause, or merely the concomitant and an aggravation of the failing condition.

If, then, it be decided that the cause of failure is not destruction by parasitic plants or insects, nor injury from excreted matters, nor the shade of a corn-crop, and that it is to be looked for in exhaustion of the soil, there will still remain several open questions. Is it exhaustion of certain organic matters rich in carbon, of nitrogenous food, or of mineral constituents? Again, is there an actual exhaustion of the substances in question, or only an unfavourable condition of combination, or, so to speak, of *soil-digestion* of them, for the accumulative and assimilative requirements of leguminous plants? Or, is there only an unfavourable distribution of them within the soil, considered in relation to the extent and character of the root-range of the crops?

These various points cannot be considered in detail within our present limits; but a few brief observations may be made in reference to them by way of explanation and suggestion.

The results obtained on the garden-soil are, of course, consistent with the supposition that there was in the field-soil a want of some of the ultimate elements of the crop. They are also consistent with the assumption that it is not merely requisite that the constituents should be present in the state of combination and of distribution available for other descriptions of crop, but that it is essential for the healthy development of the clover-plant, that the constituents should have undergone a certain digestion, so to speak, within the soil; or that certain constituents should have become more distributed than is necessary for the cereal crops. On either supposition the result may be dependent on the proper supply of carbon, of nitrogen, or of mineral constituents. Thus, in garden-soil, liberally dunged for centuries, there would be a great accumulation of all constituents. A large amount of both carbon and nitrogen compounds would have undergone considerable, if not as complete change as could take place within the soil; and their products, as well as mineral constituents, would be widely distributed.

Although, taking the whole period, carbon has been removed in the crops from all the plots in larger quantities than it has been supplied to them in manure, experience with other descriptions of crop would not lead to the supposition that the failure could be due to a deficiency of that constituent provided it were taken up by the Leguminosæ exclusively as carbonic acid, yielded by the atmosphere, or by the decomposition of organic matter within the soil. If, however, it were the case that some plants, clover, for example, required for healthy development at certain stages of their growth a portion of their carbon to be presented them in other compounds—organic acids more complex than carbonic acid, in combination, it may be, with ammonia, or with fixed bases—we could then easily understand that, under ordinary circumstances. a certain period of time might be requisite for the formation and accumulation of a sufficient amount of the compounds in question. It would also be intelligible that there should be a great accumulation of such compounds in the soil where dung had been liberally used for centuries. A fact of another kind, which is at any rate consistent with the view here assumed, is, that the ashes of the Leguminosæ we cultivate contain a large proportion of carbonate, indicating, possibly, that the fixed bases had been taken up in combination with a combustible organic acid. Again, another fact in accordance with the view is, that although a Leguminous crop assimilates two, three, or more times as much nitrogen over a given area as a Graminaceous one, the direct application of ammonia-salts, so effective with the latter, is more frequently injurious than beneficial to the former within the season of their employment; though, after some time has elapsed, some beneficial effects can be observed, apparently due to the previous supplies. An obviously possible explanation of this is, that organic acid salts of ammonia have have been formed.

On the other hand, nitrate of soda, though not a reliable manure for Leguminous crops, as it and ammonia-salts are for the Graminaceæ, is certainly much more beneficial to them than are ammonia-salts ; and, it may be, that it is not until the ammonia has in great part been converted into nitric acid, and the resulting nitrates become widely distributed throughout the pores of the soil and subsoil, that the Leguminous plant attains sufficiently active and vigorous growth, and acquires sufficient possession of the soil, to render it independent of its many enemies—whether in the form of animal or vegetable parasites, or of climatic vicissitudes which slacken its vitality, and render it an easier prey to its animal or vegetable enemies.

On the supposition that the favourable condition of the nitrogen is that of ammonia in combination with an organic acid, we have to conclude that that condition, even if favourable, is at any rate not essential for the Graminaceous crop, or that the distribution of the compounds in question is such as to render them not so readily available for the Graminaceous as for the Leguminous plants. Supposing, however, that the required condition be the oxidation of the ammonia and the wider distribution of the nitrogen in the form of nitrates than would take place so long as it remained as ammonia, that portion of the nitrogen which is supplied in manure for the Graminaceæ, and which, owing either to unfavourable combination, or unfavourable distribution, within the soil, is not recovered in the increase of the immediate crop, becomes gradually oxidated and more widely distributed, and the Leguminous crop, alternating with the Graminaceous one, and gathering from a more extended or different range of soil, in its turn leaves a residue, or allows the accumulation, of assimilable nitrogen within the range of collection of the crops which succeed it. On this view, not only does the growth of the Leguminous crop serve to arrest the loss of nitrogen by drainage as nitric acid, by bringing up again much of that which had passed in that condition into the lower layers of of the soil; but there is obviously provided one important element at least in the explanation of the beneficial effects of alternating Leguminous with Graminaceous crops in rotation.

Again, the nitric acid would, most probably in great part, be in combination with lime, which is the base occurring in large proportion in the ash of our Leguminous crops; and supposing nitrogen were taken up by the plants as nitric acid, chiefly in combination with lime, but partly with potass or other bases, we should, in that fact, have an element in the explanation of the occurrence in the ashes of the Leguminosæ of so much fixed base, and especially of lime, not in combination with a fixed acid; and we should, so far, to a less extent require the aid of the assumption that the bases in question had been taken up from the soil as ready-formed organic acid salts.

The above considerations are of interest not only with reference to the results obtained in the highly manured garden-soil, but also in connexion with the facts of the entire failure in the field at the present time where neither carbonaceous nor nitrogenous manures have been supplied, and lime has been the most exhausted, and of the partial success where carbonaceous and nitrogenous manures have been to a considerable extent supplied, and lime has been added in great excess.

It is obvious that the time that would serve for the formation and distribution of the organic acid salts, or of the nitrates, would also serve for the soil-digestion, and distribution, of mineral constituents.

To conclude, in regard to the conditions of failure and partial success in the field at the present time, it may be remarked that on some portions of the land where there is the complete failure, considerably more of those mineral constituents which most characteristically increase the growth of a healthy clover crop in the land in question, have been supplied than taken off in the crops.

This has not, however, been the case with the nitrogen on any portion of the experimental land; though, as already said, the exhaustion of it has nowhere been so great as in experiments on mixed herbage, including perennial Leguminous species. On the other hand, where there is at the present time a fairly healthy, but only small crop growing, the application of those mineral constituents which most increase a healthy plant has been considerably less, but that of nitrogen has been greater than where there is the total failure. Nevertheless, on the portions where there has been the most liberal supply of those mineral constituents—potass, for example—there is at the present time considerably more growth than where there has been no such supply.

Lastly, in regard to the attempts made to supply the fertilizing matters at a considerable depth below the surface, it is admitted that, for a time at least, the resulting physical condition of the soil and subsoil was not satisfactory; though, even at present, indications are wanting that beneficial effects may eventually follow.

This brief record of many failures may be concluded by a quotation from a paper on the subject published by Mr. Lawes and myself some years ago:—

"When land is not what is called 'clover-sick,' the crop of clover may frequently be increased by top-dressings of manure containing potass and superphosphate of lime; but the high price of salts of potass, and the uncertainty of the action of manures upon the crop, render the application of artificial manures for clover a practice of doubtful economy.

"When the land is what is called 'clover-sick,' none of the ordinary manures, whether 'artificial' or natural, can be relied upon to secure a crop.

"So far as our present knowledge goes, the only means of insuring a good crop of Red Clover is to allow some years to elapse before repeating the crop upon the same land."

IX. Notes on some Wild Pear-trees growing near Charlwood, Surrey. By W. Wilson Saunders, Esq., F.R.S.

On the high ground west of Charlwood, Surrey, the Common Pear (*Pyrus communis*) occurs, apparently wild, in several localities. The soil is stiff clay, a portion of the great Wealden formation lying between the lower Greensand and the Hastings sands. The trees are to be found chiefly in hedgerows and in the outskirts of woods and thickets, many far removed from any dwelling, and where there is no probability of their having been planted. They