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NEW ZEALAND.

THE DISEASES OF LEMON AND OTHER TREES IN NEW ZEALAND

(REPORT UPON), BY PROFESSOR KIRK.

Presented to both Houses of the General Assembly by Command of His Excellency.

Professor KIRK to the Hon. the MINISTER of LANDS.

SIR,— Auckland, 7th July, 1885.

In compliance with your instructions, I have the honour to forward herewith a memorandum on the chief diseases of the lemon and allied plants in New Zealand, with a statement of the remedies that have suggested themselves during the course of my investigation.

As your original instructions did not reach me until the growing season had terminated, or nearly so, my information is of necessity incomplete. Several injurious insects have been observed in a single stage of their existence only, so that it is not possible to identify them with any certainty at present, while a more complete knowledge of their habits and metamorphoses is absolutely essential before their extirpation can be sucessfully attempted.

On my return to Wellington I purpose completing the necessary microscopical investigations, and working up the material collected more fully than I am able to do while travelling. This will enable me to offer a report embracing all that I have been able to ascertain with regard to fruit blights, whether of vegetable or animal origin.

In complianance with the instructions contained in your telegram of the 2nd instant, I have paid a second visit to the lemon plantations of Mr. Reader Wood, and have appended an account of their present condition, but have not felt it necessary to describe other plantations and orchards at present.

In one nursery only was I able to find young plants attacked by *Icerya*, and the affected specimens were confined to a single plot. In another nursery a fruiting citron was infected, but all the young plants were perfectly clean. This is gratifying, as, although nurserymen, for the sake of their reputation, are careful to clean plants obviously infected before sending out, it is possible that young insects or eggs might remain after the mature insects have been destroyed.

I have, &c.,
T. KIRK.

The Hon. J. Ballance, Minister of Lands.

Enclosure 1.

MEMORANDUM on the DISEASES of ORANGES, LEMONS, and other CITRACEOUS TREES, by T. KIRK, F.L.S.

1. Foot-rot.

THIS appears to be the most serious disease to which the lemon and citron are subject in the colony. It is first indicated by the leaves turning yellow and falling, so that the branches are partially denuded, and the luxuriant growth of young shoots is speedily arrested; at the same time the affected tree produces flowers in profusion, and the flowers develop fruit, so that, although diseased, it may for several years carry heavy crops; but, as the disease advances, the fruit becomes smaller, and at length ceases to ripen. In the last stage the tree becomes almost leafless, yet still develops flowers, although in some cases the pollen is abortive, and the ovaries do not become fertilized. Diseased trees may linger in this state for several years.

The disease commences with the decay of the minute fibrils of the root, the fibres are next affected, the eperdermis peels off in flakes, and the woody parts of the root become decayed. At length the bark of the collar softens and rots, often emitting a nauseous odour. As the decay extends for a foot or more above the collar the bark of the stem falls away in pieces, or may be easily rubbed off by the fingers. In some cases mycelial threads may be found permeating the decaying bark, but the fungoid growth is a consequence of the decay, and must not be mistaken for the cause. If the disease ascends without traversing the circumference of the stem the tree

may continue to produce fruit for years, but if the entire circumference is affected, so that the outer layers of tissue are destroyed, death speedily ensues. An examination of the root at once shows that very few fibrils are left, and the few that remain are destitute of root-hairs. Healthy trees develop masses of matted fibres immediately beneath the surface of the soil, and the tip of every fibre is densely clothed with delicate hairs.

Causes.—Foot-rot is caused by the rootlets penetrating into a cold retentive subsoil, excessive manuring, deep planting, earthing-up, whether with wood ashes, stable manure, or with earth. In some cases, by excessive autumn pruning, leading to a late growth, and consequent development of unripened wood, the roots are stimulated to increased action, which is suddenly checked by a fall in temperature. Plants kept too long in pots, so that the roots become "pot-bound," are peculiarly liable to be attacked.

Prevention and Cure.—The degree in which remedial measures may fairly be expected to prove successful must depend to some extent upon the stage of the disease; as a general rule, so long as disease has not encircled the stem, recovery may be hoped for. The soil must be thoroughly drained, and, if of a retentive character, properly worked over before re-planting. The roots must be laid bare, and the unsound portions cut away; all traces of decay must be removed, and the roots left exposed for a week or two, unless the weather be dry and unfavourable; afterwards they should be lightly covered with leaf-mould or some light alluvial soil. The decayed bark of the stem must be carefully pared away in such a manner as not to wound the sound portion more than can be avoided. Frequent applications of tar-water to the roots and stem will be found beneficial in all except extreme cases. The disease is most frequent amongst trees growing in cold subsoils, it is rare on open volcanic soils, or where the trees have been surface-planted. It attacks the lemon and citron more frequently than the orange, and its effects on the former are more severe than on the latter. The lime is open to its attacks, but I have seen no instance of the shaddock being attacked. In some cases a gummy secretion is exuded by the affected parts of the stem, constituting the disease termed "lagrima," but I am unable to draw a distinction between the two. The exudation of gum is confined to the early stages of the disease, and ceases with the decay of the bark, so far at least as it has come under my observation.

2. *Root-fungus.*

Another form of root-decay is caused by the mycelium, or vegetative system of a fungus (*Lycoperdon* sp.), which attacks the root-fibres. This affection is more speedily fatal than ordinary foot-rot, and often spreads with great rapidity from tree to tree.

In affected trees the leaves at first turn yellow and fall away, as in foot-rot, but later they present a flaccid and drooping appearance, falling while still green. On examination of the roots they will be found more or less flecked with cottony-looking threads, which often form small matted patches, resembling the moulds occasionally seen in decaying plums or peaches. Under the microscope each thread is seen to be a delicate tube, a number of them being matted together, but not connected by the fusion of their walls, so that they are incapable of forming a continuous tissue. They constitute the vegetative tissue of the fungus and extract nourishment from the roots on which they are parasitic, so that the infected plant becomes exhausted, the entire root crumbles to fragments when touched, and the decay gradually extends to the wood. A large tree after being infested for any length of time may be easily pushed over, as even the stoutest branches of the root are acted upon by the fungus as if affected by dry-rot.

The reproductive system of the fungus in many cases is not developed: the vegatative system may permeate the soil over concealed spaces covering many square yards without a single perfect fungus making its appearance. In other cases the perfect state makes its appearance in the form of small spherical puff-balls, which rise singly or in clusters slightly above the surface of the ground. At first they are white, fleshy, and apparently homogeneous, but in less than forty-eight hours the fleshy portion has disappeared, and the puff-ball has attained its mature condition. It now consists of a thin membraneous sac or envelope containing a mass of snuff-like spores, finer than the finest dust. At length the sphere exhibits a minute aperture at the apex, and the spores escape in countless millions, so that, in addition to the indefinite underground extension by means of its vegetative system, the germs of new individuals are distributed over a wide district by the lightest breath of air.

Trees planted on fern-land are especially liable to be attacked by this fungus. In most cases it will be found that fragments of the underground stems of fern have been left in the ground, and when partially decayed have been attacked by the fungus, which thus finds a suitable nidus and speedily covers them with its white thread-like tubes. These spread through the soil in exactly the same way as mushroom spawn, and in some cases attack and destroy every plant that comes in their way. I have seen sheep-sorrel, cocksfoot, common meadow-grass, and wire-weed killed by their ravages, as well as large fruit trees.

Prevention and Cure.—The soil should be frequently turned over before planting, and care should be taken to remove fern-stems and decaying wood as completely as possible. Where lime can be procured the soil should be sparingly top-dressed, and the dressing turned in some time before planting. Root-fungus is more frequently met with in dry soils. Probably the best remedy for this affection would be to saturate the soil with tar-water, to apply a dressing of Stockholm tar sparingly to the affected parts if the disease is not too far advanced, but in any case the decayed parts must be carefully removed. Powdered sulphur may be mixed with the surface-soil, or still better with new vegetable mould, where it can be procured, and applied freely to the roots. In cloudy weather the roots might be left exposed with advantage. Wood- or coal-soot may be mixed with the surface-soil and would prove of great value. Weak-lime solutions would doubtless prove beneficial, but would require great care in their application. All decayed roots and branches should be burned without loss of time.

3. *Lemon Smut or Black Blight.*

This fungus forms a black film or coating over the surface of the leaves, and usually develops short erect filaments one-tenth to one-quarter of an inch in length. On old neglected trees every leaf may be covered with this parasite, so that the tree presents a disgusting appearance. By some writers it is said to be caused by the excreta of the large white scale (*Icerya purchasi*). This, however, is erroneous, as it is of purely vegetable origin, and has been observed infecting lemon trees in the Auckland Domain for more than twenty years, while the *Icerya* has become naturalized in the colony within the last ten years. It may be easily destroyed by dusting the leaves with sulphur or with lime or by frequent syringing with soap-suds, &c. The fruit is sometimes attacked by this fungus.

4. *Borer.*

All citraceous plants are subject to the attacks of boring insects, and in some districts their ravages are excessive. At present the material collected is not sufficient to enable me to identify the pest with any degree of certainty, as it is only known in the larval state.

Trees may be attacked by the borer without losing much of their vigour, so long as the insects are few in number; when they are numerous the vigour of the tree becomes greatly impaired, and it is less able to resist the attacks of foot-rot, white scales or other injurious agencies.

The first indication that a tree is affected by borer is afforded by a few of the branchlets presenting a withered appearance; the bark for an inch or more below the tip shrivels and assumes a brown colour, the leaves fall, and in a short time the branchet breaks. On a careful examination of the fracture a few grains of wood-dust may be discovered, and on splitting the branchlet longitudinally a small gallery will be found excavated in a downward direction, and the larval insect will be found comfortably ensconced at or near its lower extremity. The perfect female insect forms an aperture near the tip of the branchlet, and deposits its egg, which, on being hatched, commences to bore its way downwards. On reaching the base of the branchlet it continues its excavation into the branch, still increasing the diameter of its gallery, and at intervals forming shallow expansions to the right or left. At length it reaches a stout branch or, possibly, the main stem, when it bores through the bark; but whether it passes its quiescent stage at the mouth of its burrow, or whether it emerges and enfolds itself in a leaf before entering the dormant condition, can only be determined by more extended observations, as the perfect insect is unknown.

The largest specimens of the larval state that have come under my notice are about an inch and a quarter in length, and of a yellowish white colour. The body is deeply constricted between the segments, which are thirteen in number, so that each segment is more or less keeled or ridged. The mouth is small, and slightly sunk in the head. Each of the three thoracic segments carries a pair of minute-pointed legs turned outwards, and all the segments except the head are clothed with short rigid distant hairs.

The galleries vary greatly in length, the longest that I was able to trace was under two feet, the majority were from eight to fifteen inches, the greatest diameter was less than three-eighths of an inch. I was assured by one or two observers that the grub invariably made its way to the main stem. This view, however, is untenable, as the aperture by which the larva makes its exit may frequently be observed on the branches. The sudden increase in the diameter of the gallery as the borer passes from the branchlet into the adjacent branch is very striking. A small pellet of curved woody fibre is usually found near the shallow lateral expansion in the gallery. In rare instances the gallery is driven upwards, and the larva has the power of moving along its gallery either upwards or downwards with some degree of rapidity. These movements may be facilitated by the short stiff hairs which are scattered over the segments.

The eggs are usually deposited near the tips of branchlets, but other situations are sometimes selected by the female insect: a fresh wound made by accident or by the pruning-knife, or a branch broken by the wind, alike offer a suitable place for the egg. The stump of a tree nearly four inches in diameter has been attacked after the trunk has been chopped away.

Two instances here came under my notice in which injury appears to have been effected by another species of borer. In these cases the gallery was driven transversely nearly through the branch and the woody tissue excavated from each side without interfering with the bark, so that a shallow circular chamber was formed about three-quarters of an inch in diameter and one-tenth of an inch in height, but the insect escaped observation. A branch injured in this way is broken even by light winds.

Prevention and Cure.—A further knowledge of the habits of this species must be obtained before satisfactory remedies can be suggested. All wounds should, as far as possible, be covered with a thin film of tar, or some other substance calculated to prevent the deposition of eggs. Branchlets attacked by the insect should be at once removed and destroyed, care being taken to remove them below the extremity of the burrow. Probing the galleries with a fine-pointed wire and perforating the larvæ would be found effective, and might easily be carried out when the insects are few in number. Mr. Campbell, manager to W. J. Hurst, Esq., M.H.R., injects soft-soap dissolved in boiling water, with the addition of a little carbolic acid, into the burrows, by means of a syringe with a fine nozzle. He informed me that this mixture dissolved the larva, so that the outflow presented a milky appearance. It is possible that the perfect insect might be trapped in open pots containing a mixture of honey and treacle suspended amongst the branches. Trees extensively infested by the borer present a somewhat straggling appearance, the branches being partially denuded of leaves, but fruit is produced in abundance until the energy of the tree is exhausted. The least amount of harm is caused when the borings are carried on near the centre of a stout branch, or of the main stem; the greatest, when the excavations are made immediately beneath the bark. When the excavations are numerous, branches are continually broken off by the wind.

5. *White Scale (Icerya purchasi).*

This unwelcome scale-insect was first observed by Dr. Purchas on kangaroo acacia, near Auckland, in 1876, and the female insect was described by Mr. W. M. Maskell, in 1878, as *Icerya purchasi.* It was supposed to have been introduced with wattles from Australia, but it is not a native of that continent. In all probability it came to our shores with imported citrads from the Fiji Islands or from California. In some localities in the colony it is common on citraceous plants and on wattles, less frequently on furze, manuka, &c.; more rarely it may be found in the apple, plum, and peach, but I have never seen it in quantity on either. It usually forms linear masses on the twigs and small branches of lemons, citrons, &c., and on the under surface of leaves. In some cases it forms superficial patches, covering two or three square inches on the stem.

The mature female insect is fully one quarter of an inch in length. In the young state it is of a reddish-brown colour, and is furnished with a pair of short antennæ, a pair of eyes, a short beak adapted for piercing the epidermis of plants and extracting their juices, and three pairs of short legs. In this state it is oval in form and exhibits a certain amount of activity. In a few days the reddish-brown colour is obscured by a flexuous cottony growth, and the oval shape is to some extent lost. Minute tufts of blackish hairs are arranged around the lower margin of the body. The insect loses the power of locomotion and becomes attached to the twig by its suctorial beak. The nest is formed between the abdomen and the surface of the twig. The eggs are deposited in the nest to the number of fifty and upwards, and are hatched in a few days. I have not seen the male insect, but have been assured that it is not uncommon in the spring, and exhibits considerable activity, the slightest movement of a branch being sufficient to start a number of them on the wing.

Plants attacked by white scale present an uninviting appearance, but, unless suffering from foot-rot, borer, or other plagues, do not appear to become so much exhausted as might be expected from the vast numbers of the insect. No instances of fatal results from its ravages have come under my notice.

Prevention and Cure.—Young trees should be carefully examined before planting, in order to remove any scale that may have attacked them. Planted trees should be frequently inspected, so that the first appearance of the pest may be promptly detected and the insect destroyed. In this way it may be prevented from establishing itself at but little cost, but, should the orchard become thoroughly infected, its extirpation will involve a considerable expenditure of time and labour. All affected branches removed when pruning should be promptly destroyed. Syringing with a weak solution of caustic potash would be highly effective, and would scarcely need to be repeated more than once to clean the infected trees, however numerous the insects. Washing the affected parts with boiling water is one of the best modes of destroying the insect that can be adopted, but has the disadvantage of being inapplicable to young shoots during the period of active growth. Syringing the tree with hot water in which soft-soap has been dissolved is highly beneficial. Painting the affected parts with castor-oil, containing a small quantity of soot, would doubtless prove effective. All preparations containing oil must, however, be applied carefully, and laid on with a light hand. Castor-oil is an insecticide of great value, and, properly applied, is not injurious to vegetable tissue. The central portions of the tree should be kept open by early summer pruning, so as to permit the free circulation of air. In the lemon plantations of Reader Wood, Esq., of Parnell, some trees having a southern aspect are infected with *Icerya* to a great extent; others with a northern aspect are almost exempt, doubtless owing to their being in the shade for the greater part of the day at this period of the year. On account of the rapidity with which this insect increases, it must be looked upon as one of the most dangerous enemies which the lemon-grower has to encounter.

6. *Orange Aphis.*

The young shoots and leaves are frequently attacked by myriads of this minute depredator, and at first sight present a similar appearance to shoots affected by black blight: this, however, usually attacks fully-developed leaves. The colour of the insect is a brownish black, the male insect being winged. This pest is most destructive during the early spring and the late autumn, but its effects may be observed at all periods of the year. It is readily destroyed by syringing with tobacco-water, or with soft-soap dissolved in hot water, or by dusting the leaves with sulphur or lime.

7. *Snail (Helix aspersa).*

This European intruder is a dangerous enemy to all citraceous plants, and in some localities is found in large numbers: from thirty to fifty snails may be found crowded together on the stems of a single plant. It checks growth by feeding on the epidermis of the young branches and leaves, and is especially fond of the epidermis of the young fruit, which it speedily disfigures and renders unfit for market. In spring they are clustered together in large numbers, and may be easily collected and pounded for the benefit of pigs and poultry.

8. *Leaf-scale.*

Of these insects two species, if not three, have been observed on the leaves and young twigs of oranges and lemons, but, so far as I am aware, not in sufficient quantities to cause serious injury. I must reserve my remarks upon them for a future occasion. They may be destroyed by washing with castor-oil containing soot, or with soft-soap dissolved in hot water.

Other enemies of the lemon and its allies in the colony are thrips, the grass-grub, caterpillars of several small moths, cicada, phasma, wood-lice, and lichen, but their attacks are rarely injurious to any great extent. I purpose refering to them at greater length on my return to Wellington.

Enclosure 2.

NOTES on Mr. WOOD'S ORANGE and LEMON PLANTATION, Parnell.

THE plantations comprise between two hundred and two hundred and fifty orange trees, lemons, and citrons, covering an irregular area of about two acres, including detached clumps and short rows. The soil was trenched two spits deep and drained; the subsoil is a cold clay. Mr. Wood informed me that over two hundred and fifty trees had been planted, nearly all of which had flourished for some years, but that many had died out, so that the actual number was below two hundred and fifty. The oldest trees have been planted about twelve years; a few are worked, but a large number are on their own roots, either seedlings or raised from layers; the latter mode of propagation being a favourite with Mr. Wood. Amongst his seedling oranges two or three give fair promise of future excellence. The majority of the trees grow on a sloping surface, so that the soil has a tendency to collect at the base of the trunks, but attention is paid to correct this unfavourable condition, and many specimens have the collar close to the surface. The largest specimens are from 10ft. to 12ft. high and carry heavy crops; this is especially the case with the Lisbon lemons.

Mr. Wood finds his chief difficulties arise from foot-rot, borer, *Icerya*, and lemon smut. He considers that foot-rot is chiefly caused by the cold, damp subsoil, a view of the case in which I fully concur. Nearly all his losses have arisen from this cause, many of the trees having been attacked five or six years ago. At the present time many of his trees are suffering from this disease, which is unquestionably the most serious to which lemons are liable in New Zealand. On laying bare the roots they were found to be destitute of fibrils, although in most cases laden with fruit. Healthy trees growing within a few yards formed dense masses of fibres immediately beneath the surface. In some instances the affected bark was making efforts to shake off the disease. If the decay in these trees can be arrested by the application of tar-water, and the growth of new rootlets promoted by the renewal of the surface-soil, recovery will doubtless be effected; but the cold nature of the subsoil must always exercise an unfavourable influence.

The borer seriously aggravates the effects of foot-root, although Mr. Wood's trees are less troubled with this pest than others in the same district.

White-scale is plentiful on the branches and leaves of many trees, and in a few cases has spread, although sparingly, to adjacent apple and peach trees. It made its first appearance in the orchard three years ago, and, having been allowed to pass unchecked, soon made rapid progress, especially on trees having a southern aspect. Mr. Wood is now applying soap-suds freely with the syringe, with every prospect of good results. Lemon smut receives similar treatment.

Mr. Wood has sustained serious losses from the ravages of foot-rot, and some of his trees are still further exhausted by the attacks of borer and *Icerya;* but I am firmly of opinion that the ravages of these pests may be arrested and kept within bounds in the future by the persistent application of the remedies suggested.

By Authority: GEORGE DIDSBURY, Government Printer, Wellington.—1885.

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