PESTS AND DISEASES.

RED RING DISEASE OF THE COCONUT.

S. F. ASHBY, B.Sc.

Professor of Mycology, Imperial College of Agriculture.

The following paper on "Red Ring Disease of the Coconut" by S. F. Ashby, B.Sc., together with the discussion thereon, are taken from the *Proceedings of the Ninth West Indian Agricultural Conference*, Jamaica, 1924:—

This is a fatal parasitic infectious disease recently recognised as of wide distribution in the West Indian Region but known for nearly 20 years under the name of root disease in Trinidad and Tobago. It is present in Honduras, British Honduras, Panama, Venezuela, British Guiana, Trinidad and Tobago, Grenada and St. Vincent but has not yet been definitely reported from the Greater Antilles. The evidence suggests spread by means of seed nuts so that it may have been introduced already from Central America into one or more of the Greater Antilles. Coconut planters in Jamaica should therefore be acquainted with the symptoms and the nature of the parasite.

It is characteristic of the disease that trees approaching bearing age or recently come into bearing are most subject under plantation conditions and that after causing losses for a few years the attack may wear off. It is therefore usually in the 4th or 5th year that the early cases may be looked for and after increasing in number for two or three more years, there may be a gradual or rapid falling off of fresh cases by the 9th or 10th year. Before the disease abates the loss of trees may amount to or exceed 30 per cent. in Trinidad or Tobago.

Symptoms of the Disease as described by Nowell and seen by the Writer in Grenada and Trinidad.

External Symptoms.—The first indications in trees already in bearing are the shedding of green nuts in all stages of development and withering of opened or unopened inflorescences. There follows a progressive yellowing and browning of the leaves from below upwards beginning at the tips, involving finally leaves not yet fully expanded. The oldest leaves may however not be the first affected. The leaves eventually give way and hang down or break 1-2 feet above the base. If the tree is allowed to stand the heart leaves wither and the central column falls over.

These symptoms resemble closely those associated with the form of budrot attributed to bacteria and as a fact in both Red Ring and Budrot the final condition is a soft stinking rot of the bud.

Internal Symptoms.—These are quite characteristic and distinguish the disease at once from any form of bud-rot infection or otherwise.

In the stem there is a continuous dull red ring, 1-1½ inches wide, and 1-2 inches from the surface extending upwards from the base to a height of 4 feet or more, and then breaking into red streaks and scattered red dots up into the tender tissue below the growing point. In rare cases where the young leaves are the first to fall, the red zone may be central in the stem.

The leaves when split lengthways through the middle of the stalks show a dull red or sulphur yellow streaking and mottling from the base for 6 inches to 2½ feet, and this may be present even in young leaves which are still fully green.

The internal streaking and mottling in the leafstalks is often succeeded and marked by a diffuse wet brown rot of secondary origin, due usually to the common saprophyte *Diplodia theobromae*. It is doubtless the cause of the leaves hanging down or breaking across in the stalks.

The roots may be affected to a very variable degree. When diseased the normally moist white spongy tissue between the hard rind and the central strand becomes dry and flaky, and discoloured yellow to reddish brown.

Cause of Red Ring.

If a fresh scrap of the affected tissue from stem, leaf, stalk or root is teased up in a drop of water and magnified 20 to 50 times, eelworms, frequently in active motion, can be seen. Eggs, larvae of various sizes and fully grown male and female individuals can be found together especially in the stem and leafstalks, but less frequently in the roots. This eelworm or nematode, therefore, breeds freely in the ground tissues of the tree, moving in the intercellular air spaces and puncturing the cells with a delicate spear protruded from the mouth which sucks up the escaping sap. The fully grown males and females are about ½ mm. in length and only 1/140th mm. in breadth. The larvae depending on age vary in breadth from 1/8 to 1/3 of a mm. The eggs straight or slightly sausage-shaped are about 1/24th of a mm. in length and 1/140th of a mm. broad. The worm therefore looks like a flexible needle when in motion.

Mr. Nowell, who was the first to observe the association of the nematode with the characteristic symptoms of the disease in 1917 in Grenada, found it present in all cases seen subsequently in Grenada, Trinidad and Tobago, and his findings have been confirmed by investigators in Central America. As the roots are not always affected and the red zone in the stem is a constant feature of pronounced attack he proposed to substitute " Red Ring " for the older less appropriate name " Root Disease," and his suggestion has been adopted generally.

Infection Experiments.

The first cases seen by Nowell in Grenada were on a Government plot of 68 trees planted in 1912 at Westerhall. Deaths from disease on this plot had begun about 1916 in trees planted 4 years before. In 1919, inoculation experiments were carried out on healthy looking trees (1) by inserting fragments of tissue taken from the red ring in a diseased tree into auger holes in the stems 1-2 feet above the ground, the holes being closed with tarred plugs of deal. After 60 days the three inoculated trees were felled and cut up, and were found fully infested with the nematode in stem, leafstalks and heart, with a pronounced red ring from the base to the bud. Adjacent trees remained healthy.

(2) By dropping fragments of diseased tissue 1-2 inches long and of similar origin into the crown without wounding. After 74 days the nuts on one tree had been shed and the leaves were yellowing and turning brown. All the leafstalks were infested by the worm and the red ring in the stem was pronounced from the base to a height of 8 feet,

Another tree which had only one fragment dropped among the young leaves was examined also after 74 days. Twelve leafstalks were found to be internally discoloured and infested by the worm.

You will note that when the inoculation was made near the base of the stem the worm worked up internally into the leafstalk and that when infected tissue was introduced into the crown, the worm entered the tree and worked down to the base of the stem; the trees were practically dead in 2-2½ months.

In 1921 I had some further inoculation experiments begun on the Westerhall Plot. Bags containing 5 pounds of salt were put above the heart of 8 trees now 9 years old and infested fragments of tissue were dropped into the crowns after 2 weeks. Two and a half months later all the trees were showing marked external symptoms of disease and were cut down and examined.

Two showed full infestation in leafstalks, stem and roots. Four were infested in the leafstalks and upper parts of the stem, which were internally of normal colour and free from the worm to a height of 2, 6, 7 and 8 feet from the ground, respectively. All four, however, were infested in the roots. In the remaining two trees the red ring was very faint in the stems 9 and 18 inches above the ground and no diseased roots were found. In half the trees there had been an infection at both ends—crown and roots, but the worm had not entered the stems from the roots. In two trees no independent infection of the roots had occurred and as the worm and red ring had not quite reached the base of the stems the roots were still sound. The salt drip had evidently neither prevented nor delayed infection in the crowns.

In another experiment begun at the same time infected pieces of stem tissue from a diseased tree were buried in the soil to a depth of 2 inches in a circle 18 inches from the stems of 16 healthy-looking trees. Salt was mixed with the soil round 8 of these trees. After 5 months ten of the trees showed suspicious external symptoms and these were cut down and examined during the succeeding six weeks. All were found fully infested by the worm in roots, stems, and leafstalks, and all showed a well developed red ring. Of the remaining six trees five were infested in the roots but borings at a height of 6 feet gave negative results. Two of these trees died from the disease about 6 months later; the other four are still alive. The most obvious inference is that the ten trees became infected in the roots by the nematodes escaping from the buried fragments of infected tissue and that the worms entered and worked up the stems from the infected roots. This conclusion was not quite established as the trees were not fully infected when cut down, moreover, a severe storm two months after the experiment was begun, injured the tops and rendered them attractive to palm weevils which in Central America have been observed to carry living worms on their snouts. I have been told by a mycologist who has studied Red Ring in Central America that he had cut down apparently healthy trees in badly infected plantations and found the red ring only in the basal part of the stem evidently due to infection through the roots. Salting the soil proved ineffective. At Westerhall 3 trees planted 2 years, and one planted 11 months were inoculated by dropping infected stem fragments among the leaves. After 2-2½ months all showed marked external signs of disease and were found to be fully infested. During the last two years several more 2-year-old supplies on the plot have

died from Red Ring. Although as a rule the earliest cases on plantations do not show under four years, it is evident that younger trees can be infected and killed. In co-operation with Mr. R. O. Williams, at that time Agricultural Superintendent in Grenada, I inoculated full-sized green nuts by inserting an infected fragment into each husk. After 26 days the nuts were examined and found to show a distinct red ring halfway between rind and shell and a darker zone in contact with the shell. The nematodes were abundantly present in both zones. Although the worm has not been found in the husks of coconuts on diseased trees the result of this experiment indicates that nuts which have dropped may be infested from the soil through wounds in the husks, and the worm may multiply in the husks provided the tissue is still sappy. The larvae are very sensitive to desiccation when dried naked on grass and exposed to the air, losing their vitality in a day. It is probable that like a number of pathogenic bacteria and fungi they, especially the eggs, may withstand desiccation for a relatively long period when dried gradually in a vegetable tissue like coconut husk. In Trinidad Red Ring has appeared on young cultivations on land cleared from forest and far removed from infested plantations; these outbreaks seem to point to infection carried in the husks of seed-nuts. The disease has been present in Tobago for many years and was probably introduced into Grenada and St. Vincent in seed-nuts from that island. The disease is apparently endemic in parts of Central America and seed-nuts from there, unless from plantations definitely known to be free from Red Ring, should be regarded with strong suspicion. Two seedlings taken from the nursery at the Botanic Station in Grenada were inoculated in the husks and replanted in pots. After three months several roots on each were infested and the worm was breeding in them, but the plants were quite sound in the stem and leaves. Some experiments are now in progress at Westerhall to determine whether seedlings inoculated in the husks when planted out become infected in the roots and how long this infection can continue before trees become perceptibly diseased. It is possible that the nematode may maintain itself in some of the roots of seedlings for several years before infesting the stems and leafstalks and killing the trees.

There is evidence at Westerhall and elsewhere that the disease can spread from tree to tree, but the problem of just how this occurs and the place on the tree where entrance is most liable to be effected have not yet been solved. It is safe to assume that the great breeding ground of the worm is in the ground tissues of the living tree especially the stem and that it is of great importance that the early cases be promptly detected and thoroughly dealt with. These may be quite few in number in a plantation so that vigorous action may be effective in stamping out the disease before it makes headway. The external symptoms in the leaves will arouse suspicion and a boring or some chops with a cutlass into the stem to a depth of about 3 inches 2 or 3 feet above the ground level will confirm it. As a rule, the tree will be fully infested and should be completely destroyed by fire. A method which has worked well at Westerhall is to dig up the tree, chop up the stem and leaves into short sections, and pile them into the hole, start a fire with the dry trash and cover with earth so that the material will burn slowly for several days, as in the method of burning charcoal.

Nowell has observed that in some plantations which are trenched between the rows the disease has been found to follow along the row without crossing the trenches. This suggests that the spread of infection in the rows might be sufficiently controlled by isolating the infected spot with cross trenches after burning the diseased tree and as an additional precaution isolating the adjacent trees on each side by further cross trenches.

In conclusion, I may say that a well illustrated account of Red Ring can be found in Nowell's recently published book "Diseases of Crop Plants in the Lesser Antilles," which should be in the hands of every progressive planter in the West Indies.

RED RING LITERATURE.

Nowell, W.		
West Indian Bulletin	Vol. 17, p.p.	189—210
do do	Vol. 18 ,,	73— 76
Agricultural News	Vol. 17 ,,	398
do do	,, 18 ,,	398
do do	,, 19 ,,	222
Ashby, S. F.		
Agricultural News	Vol. 20, p.p.	334 & 350
do do	,, 21 ,,	March 18
Cobb, N. A.		
West Indian Bulletin	Vol. 17, p.p.	210

Nowell, W.

Diseases of Crop Plants in the Lesser Antilles.—London. 1923.

I may say this is a book by Mr. Nowell on this disease, which deals with the subject very completely and comprehensively. It is also profusely illustrated and should be in the hands of every practical planter and agricultural officer. It is sold at 12/6, and at the price is one of the cheapest books on the market, and should be in the hands of a very large number of people interested in coconut planting.

SIR FRANCIS WATTS: Mr. Nowell, will you supplement Mr. Ashby's remarks.

MR. NOWELL: Mr. President, ladies and gentlemen, I have very little indeed to add to the admirable account of Red Ring disease given to us by Professor Ashby. There are certain points of detail on which one might discourse, but such discourse would be hardly interesting to the general Conference. But I think perhaps it is necessary that I should make one or two general remarks regarding the incidence of the disease, so that if you see it in Jamaica as you probably will sooner or later, you will know how much or how little you will have to fear. Our experience in Trinidad of this disease is now rather lengthy and fairly advanced. It is a disease of adolescence in coconuts. I have met planters whose estates were aged 7 or 8 years, and where they had this disease, and they told me they would be very glad to sell the whole of their trees at Re. 1 a piece and get out of it: I met these same planters a couple of years later, and they put the price of their trees at $ 5 each, the reason being that at the time they looked like losing the whole of their cultivation we found the cause of the trouble. The difficulty, and it is a real one, is that there is very little exterior evidence of the cause of the infection in its early stages. In the meantime you may have lost 30 per

cent. of your coconuts, and you do not know how many of the seedlings you put in are going to succumb in their turn. We have not got sufficient data in Trinidad to make any definite pronouncement on the subject. The point I want to emphasise is that not only is there no cure for it, but I have no hope that any cure will ever be found. I know it is said that experiments have been made of injecting Thymol into trees, like they do for hookworm, and it is claimed, with good results. But I do not think the use of Thymol as a cure will be practical for the reason that you do not know a tree is sick until it dies, or it is at a stage just previous to death. External signs do not appear until the tree is doomed, or already dead, then the red ring is found in all such trees. When the first case is found, it is my experience that it is very far gone indeed. You plant your field, and four or five years later you find just one plant here and there, perhaps widely scattered, showing symptoms of this disease. The evidence all goes to show that these are cases which arose from the original case, but not from a progressive development of the original infection. What I mean is, you get these spasmodic cases continuing the infection. Then you go further, you get one plot infected, and then another, and then you have this 30 per cent. loss, which is very largely a matter of second infection from the few cases that first arose. It is obvious if you are going to meet with this loss, that it will certainly pay to dig up all the trees in the infected area, and make a charcoal pit of them, rather than being merely content at chopping down the infected trees, and saying you can do nothing more. It is the height of economy to spend any money necessary to deal with the first cases, and get them very thoroughly destroyed, because you are combating not only that original infection, but all cases that would eventually arise from it. The only safe criterion for diagnosing red ring disease is the presence of the red ring. There are other appearances, which while quite characteristic, are also shared by other coconut diseases. In Trinidad, I myself would never dare to diagnose a case as being Red Ring unless I had actual facts, and the characteristic effects produced by the disease. Once this is seen, you cannot fail to know the disease. Professor Ashby has mentioned the matter of infection, and its introduction. This is very difficult to trace. It is no easy matter to find, owing to its surroundings, an animal that measures a millimetre in length and very much less in width. It is very difficult to determine and state positively, how infection was introduced in Trinidad, but the general evidence points to outside causes—that the infection was imported. The remedy for this would be to prohibit importation. There is another alternative known as disinfection, but I think it may be stated with a considerable amount of truth that while we all recognise the measure of protection we get from spraying, it has to be thoroughly done before they would probably be quite safe as regards infection. So that if it were desirous to introduce in Jamaica from outside sources a very desirable kind of coconut, you have to be quite certain the spraying is done by a responsible person. Of course, if when the coconuts were taken from the tree they did not rest on the ground, that would probably be an effective method, but at the same time the risk of getting in a trouble you have not already got in is so great that in my opinion such introduction should only be made under the care of the Department of Agriculture, and under very careful conditions even then. Red Ring disease, as I have pointed out, is one of the most serious diseases that the coconut planter has to face; most of the great loss of money it has caused to the estates of Trinidad

and other places is due to the neglect of fairly simple and obvious precautions that could have been taken. I do not think the disease is one which compares with other troubles, which face the coconut planter, such as the Red Rot, which really are very serious for the simple reason that we have not yet found out how they are caused, and therefore cannot take any rational precautions for their prevention. Another method of precaution was alluded to by Mr. Ashby, and I think it is quite sound—the method of trenching. I have noticed in Tobago, where the trees are down with Red Ring that the diseases always progress in straight lines. On the last occasion when I was in Tobago a few months ago, I noticed there were 18 trees that had it in a row, but there was no evidence of the disease on either side of the trench. It does not appear, that trenching, particularly in a serious patch, at any rate, is an effective method of checking the disease. The place at which infection take effect, I find it rather difficult to accept what Professor Ashby has said with regard to root infection. I have carried out a large number of injections in the tops, with the result that the infected plants had died immediately. It was just the reverse with infections in roots. While I have never failed to get infection through the roots, the experiments I have carried out on a good many trees, getting infection through the roots, have failed to produce the death of the tree. The roots were infected, but the infection had not progressed in the tree to the top. Another point that makes me doubtful about root infection, is that trees escape infection once they get beyond a certain height. If infection took place by roots I see no reason why a tree 30 feet high should be any more immune than one 5 feet high. My experience is that the taller the tree the less chance of infection, while if it was communicated through the roots height would make no difference. There are, however, several points in the matter which need to be cleared up, and I hope you will not be scared about this disease, but will be able to give it a rational reception should it ever arrive in Jamaica.

MR. H. H. COUSINS: I think it might comfort our friends in Jamaica to realise that the Government of the country have absolutely prohibited the introduction of coconuts into Jamaica, and it can only be done by the special intervention of His Excellency the Governor. And so long as I act as his adviser I will see that no coconuts shall be admitted here, however desirable they may appear to be. We prefer to stick to our own coconuts and do the best we can with them.

SIR FRANCIS WATTS: Does any one want to ask any further questions about this disease, which is gradually spreading in the West Indies? So far, it would seem that Jamaica is free from it, but it would be unwise after our experience with the budrot disease that we should leave any precautions untaken. As both speakers have stated, it is one of the easiest diseases to diagnose and recognise. The strange thing is that for years it could defy investigations in Trinidad, while continuing to spread. No clear and correct diagnosis was made until Mr. Nowell found out what it was, and then it was wide-spread in the islands and also very widely in Central America. Immense areas in Central America are devastated by the disease which remained unknown until found out by Mr. Nowell, who has rendered a big service to science in this connection. He has told you that once a tree is attacked there is no cure for it. It is no good attempting to treat that tree—to save it. If a tree is found infected, at whatever stage the infection may

be, it should be cut down and burnt at once. I should like Professor Nowell to tell us something more of the rate of infection, and virulence, and in addition, if he has found the disease in other things than coconut palms—if he has found the existence of the minute organisms in other things than the coconut palm. In view of what has been said about this disease of Red Ring, I would strongly advise all interested in coconuts to examine every suspicious case where the appearances are Bud Rot, and bore a hole with an auger to see whether it is not Red Ring. It is most easily diagnosed.

MR. NOWELL: I have not got the exact details in my possession, or any memory of the incidence of the disease in its relation to certain of the palms. I carried out experiments a few months ago at the experimental station at Trinidad with the Gru Gru Palm, and the Cabbage Palm. In the Cabbage Palm the results were so remarkable, that I do not believe them even yet, although I have the figures duly filed, and I made the experiments myself. We had young trees growing, forming an avenue at St. Clair Experimental Station, with no suspicion whatever of Red Ring. The height of some was 8 to 10 feet, at which size the Cabbage Palm tissue is very soft and spongy, and offers a very suitable medium for the development of disease. I introduced small sections of Red Ring into the trunks and in less than three weeks the zone of infection had spread from top to bottom, and some of the palms were absolutely moribund if not quite dead all the way. The ring had a diameter of 18 inches at the bottom and 6 inches at the top and was 8 feet long; each fragment was so fully infected that when placed under a microscope it appeared as if you were looking at a basket of eels. Then the rate of growth was so phenomenal that I can hardly believe it yet. The Gru Gru Palm which is very much harder, gave no such striking results. The trees were 30 feet high, and it took 8 weeks before the infection reached from the base where the injections were made, to the top of the palm. But even that is extraordinary, when you consider the hardness of the stem of that palm. One or two other palms I have tried have shown no evidence of infection. But I have proved that other palms besides the coconut can be infected, and it may be that this disease is a native of some other palm in Central America, and has been distributed on the seeds of the coconut, and has found in the coconut a suitable host.

SIR FRANCIS WATTS: We have on the agenda a general discussion on the coconut industry. Does any one wish to say anything on that head? I don't know if any one wishes to speak on the subject generally or not.

MR. MURRAY: I would like to ask a question with regard to Red Ring disease. I would like to ascertain if there is any discolouration of the stalk by which it can be ascertained, or if the disease is only to be found in the inside tissues.

MR. NOWELL: The answer is no. There are no external symptoms, nothing external by which the disease can be indicated. The heart leaves are generally so discoloured by other parasites, that this minute animal cannot be seen, and even this is no guide, for sometimes the leaves are not infected, while at the same time the inside of the trunk is fully infected.

SIR FRANCIS WATTS: Is there to be no other discussion in regard to other aspects of the coconuts? We have only dealt with one aspect of the diseases of coconut. If there are no further observations then I will ask Professor Ashby to give us his observations on "Wither Tip of Limes."