RUBBER.

LEAF DISEASES OF HEVEA.

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INTRODUCTION.

Having dealt with the root and stem diseases of Hevea, the writer proposes to discuss the significance of the diseases of the leaves and fruits (capsules or pods). Judging from the general attitude adopted towards the question of leaf disease, one would infer that at present there were no serious diseases calling for attention. But in actual fact this is far from being the case.

It is much to be regretted that the deciduous nature of Hevea has led to a false impression in the minds of some that the disease factor is suppressed by the annual leaf fall. It is incorrect to assume that because the diseased leaves are shed the disease is itself thrown off.

On the contrary, as the individual trees do not winter simultaneously, some trees may be quite bare, while others have either produced new leaves or have yet to "winter." Thus, the disease cycle is continued infection of the recently produced foliage resulting from trees still in possession of the previous year's leaves. Again, certain leaf diseases may affect the twigs, etc., of the branches which bore them, the hyphae growing up again through the leaf stalks and causing a secondary leaf fall. The spores produced from the hyphae in the fallen leaves have also to be taken into consideration, thus constituting a third source of infection.

It should therefore be realised that Hevea can be crippled to the same extent by leaf disease as any other perennial, that a repetition of an epidemic comparable to that of *Hemileia vastatrix*, which resulted in the devastation of the coffee areas in Ceylon towards the close of last century, is highly probable if the question of control is not taken in hand.

In South America the leaf disease caused by *Fusicladium macrosporum* has already led to the abandonment of large areas of rubber because people have failed to realise the significance and potentialities of a serious leaf epidemic.

The exhaustive effect on the tree, occasioned by abnormal leaf falls must lead to its ultimate death.

THE LEAF DISEASES OF HEVEA.

A distinction must be made at the outset between the fungi causing leaf and fruit diseases of Hevea, which are known to occur in the Eastern and Western Tropics respectively.

The leaf diseases of Hevea are due to the incidence of the following fungi :—*Catacauma Huberi*, *Fusicladium macrosporum*, *Scollcotrichum Heveæ*—*Phytophthora Faberi and Meadii*, *Glæosporium alborubrum*, Oidium sp.—*Helminthosporium Heveæ*, *Phyllosticta Heveæ*, *Ascochyta Heveæ*, *Guignardia Heveæ (Sphærella Heveæ)*, Sooty moulds, Aschersonia, Thread and Horse Hair blights, and the red alga *Cephaleuros parasiticus*.

With the exception of the first three, recorded from South America, the above have been known to occur in the tropical zones of the East.

Abnormal leaf fall is occasioned by Phytophthora, Glœosporium and Oidium, the first two also being responsible for pod rot. The spotting and blotching of the leaves is caused by Helminthosporium (Bird's Eye spot) and Phyllostice; it should be mentioned that many other fungi are known to occur in the spotted areas of dead tissue, but the majority are in the main saprothytic following in the wake of the parasitic organism—a common phenomenon in plant pathology.

The rim blights include *Ascochyta Heveæ, Guignardia Heveæ, Sphærella Heveæ*, their presence being heralded by the dying back of the leaf margins producing a rimming effect. It is often easy to confuse the black patches produced on the leaves by Sooty moulds (Meliola, Chaetopeltopsis, etc.), with an attack of Phytophthora, but the former are superficial, living on the secretions of scale insects and the "extra-floral" nectaries of the leaves; like Oidium they are superficial, but unlike Oidium, which produces Laustoria, penetrating the epidermal cells, they are comparatively innocuous. Aschersonia is another fungus, apart from the Sooty moulds, which parasitives scale insects.

The thread blights include both epiphytic and parasitic forms, while *Marasmius equicrinis* (horse-hair blight) spreads over the leaves in an epiphytic manner. Red rust, occasioned by Cephaleuros, is rare, attacking trees when in a very poor state of health, and is easily thrown off by improved cultivation.

The chief sources of danger are at present to be found in the fungi producing abnormal leaf fall. The significance of Phytophthora is twofold, as the spores are washed down the trunk of the tree from the diseased leaves and decaying pods, *P. Meadii* causing Black Stripe of the tapping surface and *P. Faberi* the patch or claret-coloured canker.

THE SYMPTOMS OF DISEASE.

Any departure from the abnormal in the appearance of the leaves is not necessarily an indication of disease. The presence of blotched and spotted areas of brown tissue may be due to the effects of extremes of sunlight, shade, etc. But when the dead areas, wilted leaves, marginal leaf curl, and abnormal leaf fall can be correlated with the presence of fungal fructifications, there need be little doubt as to the causal agency.

The surest indications of disease are to be found in the specific effects produced by the parasitic organisms on the tissues of the host.

In the case of Glœosporium, Phytophthora and Oidium the symptoms are readily recognisable. In Glœosporium the appearance of a dark, pinkish covering on the affected fruits and pink pustules on the leaves indicates the presence of the fungus; in Phytophthora the fruit walls assume a black, patchy sodden appearance, and similar dark olive discolourations appear on the leaves; while in Oidium the presence of a white powdery layer on the under surface of the leaves in particular often suffices to identify the fungus. The Bird's Eye spot fungus (Helminthosporium), as its name implies, produces white spots on the leaf with a dark purple border, succeeded by the black pinhead fructifications of the fungus. But in the case of Phyllosticta, as with European species on the chestnut, grape, etc., there are no remarkable features of the disease; brown dead areas of tissue are produced, dotted with small black pycnidia.

The rim blights, on the other hand, produce a characteristic margin of dead tissue, bounding the leaf area; while the Sooty moulds produce a black powdery film on the leaf in contrast to the small yellow "warts" produced by Aschersonia.

The Thread blights are present as narrow white cords of tissue, travelling over the leaf surface, while the black horsehair-like strands of *Marasmius equicrinis* binding the leaves together cannot fail to excite attention.

The Red rust, Cephaleuros, owing to its rarity, may be overlooked; when present it results in the production of small areas of purple discolouration from which the red Sporangiophores arise.

Definite symptoms such as these should enable the planter to be on the alert and solicit the advice of the local experiment station, as a precautionary measure against the outbreak assuming epidemic proportions.

CONDITIONS FAVOURING THE INCIDENCE OF DISEASE.

Many factors are associated with the invasion of leafy tissues by parasitic fungi, such as the incidence of light, moisture content of the atmosphere and leaves, temperature, age and structure of the tissues, nutritive balance of the plant, and inherent properties of resistance to disease, etc. For our purpose the temperature relations and properties of resistance may be omitted.

In close planting and overcrowding ideal conditions for the growth of parasitic fungi obtain. The moisture content of the air rises, while the incidence of light on the leaves is reduced, with the result that a luxuriant growth of hyphæ is produced and the percentage germination of the alighting spores increased. By systematic thinning out and pruning these conditions are avoided to a great extent and the growth of the parasites checked.

The light and moisture factors, coupled with the nutritive balance relationship of the plant play an important role in the structure of the epidermal tissue. Provided the available potash in the soil is sufficient for the ideal growth of the plant and is not exceeded to a marked degree by the available nitrogen (in the form of nitrates or ammonium salts), the leaf produces a well-developed cuticle the light and moisture factors being favourable. If, however, the leaves are shaded and the moisture content is high, little or no cuticle is produced; the epidermal cells then assume a "watery" appearance and are much larger than under normal conditions.

When such conditions prevail the penetration of the germ tubes as opposed to their entrance *via* stomata is considerably facilitated, and the percentage infection becomes more marked.

The same observations apply to newly-formed leaves; the suberised cuticle is not developed to the same extent as in older tissue and there is little or no obstruction to the entrance of the parasite.

THE SIGNIFICANCE OF DISEASE.

The leaf diseases of economic crops, and more so in the case of perennials, are much more sinister in their meaning than the diseases which affect the root systems and stems; sinister (in the case of Hevea) in so far as the expense entailed in their control is apt to damp the enthusiasm of those applying remedial measures, and in so far as a serious individual disease can cripple vast areas of rubber beyond all hope of recovery.

Parasitic fungi show a remarkable range of adaptation to new hosts. The appearance of a novel disease is not always due to the presence of a related host, although this factor should always be taken into account as exemplified by the first appearance of *Hemileia vastatrix* on coffee, which is now believed to have originated from an indigenous and related rubinaceous host.

The power of adaptation becomes more marked with time, till the fungus is established in the tissues of the new host plant.

At present there are three serious leaf diseases of Hevea which must be controlled if the trees are to flourish in the affected areas. In the course of time this number will be increased and the affected rubber may, in part, be wiped out, if the necessary steps of control are not undertaken. The diseases in question are those which are responsible for abnormal leaf fall. Every planter should be familiar with the behaviour of the various diseases, and prompt measures of control should be adopted if in his opinion their presence is causing appreciable damage to the leaves. For the leaves are the laboratories of the plant in which the synthesis of carbohydrates and amino acids proceeds; once these have been crippled by parasitic fungi the whole plant suffers from the effects of starvation, resulting in a gradual lowering of vitality and ultimately in the death of the tree.

The effects of repeated defoliation have already been instanced in the case of South American leaf disease (*Fusicladium macrosporum*,) while in the East Phytophthora bids fair to produce similar results, if the rubber is not assisted in throwing off the parasite by the introduction of a recognised system of spraying.

CONTROL MEASURES, GENERAL.

Apart from the breeding of resistant varieties, there are two aspects to be considered in the control of a leaf disease, namely the suppression of conditions which render the plant more susceptible to disease and the arrest of the growth of the parasite by suitable methods of spraying. The first aspect may be dismissed briefly by emphasising the importance of thinning out, pruning and soil aeration, for reasons already discussed.

A system of manuring, when possible, should always be adopted. An application of even 1 lb. ammonium sulphate or chloride, supplemented with half to three-quarters of a pound of potassium sulphate or chloride per tree, will considerably increase the resistant capacity of the tree to disease, apart from improving the yield.

In soils with a greater relative deficiency of phosphate to potash, half to a pound of bone meal (basic slag) or superphosphate could be substituted to advantage. When considerations of transport have to be taken into account ammonium sulphate or chloride is recommended as a nitrogenous manure, being cheaper than sodium nitrate and containing more nitrogen per unit (43 lb. of nitrogen are contained in 206 lb. ammonium sulphate as opposed to 275 lb. of sodium nitrate,) while ammonium chloride contains even more nitrogen per unit (43 lb. nitrogen in 168 lb. ammonium chloride).

Organic residues, such as dried blood and cakes (castor cake, groundnut cake, etc.) are also to be recommended.

But the universal adoption of methods, which render the tree more resistant to invasion by parasitic fungi, cannot by itself eliminate the disease factor from a plantation. It will certainly tend to lower the percentage of diseased trees, but it must be coupled with a definite system of spraying if the desired results are to be obtained.

SPRAYING.

There is nothing to be gained by stating that a system of spraying is out of the question, when the only alternative is the abandonment of the affected areas. Without doubt the technique of spraying is *the* question of the future, and it is the duty of everyone concerned to concentrate their attention on such a problem and not grudge the means whereby mycologists and chemists will be enabled to carry out the necessary research.

It is useless to wait till it becomes absolutely imperative to spray large areas of rubber or abandon them. Experimental spraying is already in progress and good results have been obtained by Ashplant in South India. But it still lacks the stimulus and encouragement to warrant its success. The scope of this work must be considerably enlarged, more mycologists and chemists must be employed, and the research if it is to be carried out at all must be undertaken now, otherwise estates will not be able to combat the disease factor with the present impoverished methods of spraying, and capital and labour will be wasted when they might have been fruitfully employed.

The difficulties are admittedly great, but in the course of time it is hoped that they will be overcome.

FUNGICIDES AND THEIR PROPERTIES.

Both the sprays and spreaders or adhesives must be cheap and effective. The efficacy of a spray depends on its toxicity to the parasite effect on the host plant and its "weathering" capacity. The solubility and dilutions must not be such as to scorch the foliage, and the nature of the spray must not be such that it is readily removed from the surfaces of the leaves by dew and heavy rains.

The application of such substances as lead nitrate, copper sulphate, formalin, etc., are not to be countenanced, as the washes would be quickly removed by the first downpour of rain.

At present the most widely used fungicides are compounds of copper, arsenic and lime-sulphur mixtures. It is to be hoped that the application of waste dye products and fluorides will subsequently find a place in the armoury of the mycologist. Coal tar fractions may also be employed, but their application will be relevant to their cost and weathering capacity.

The use of copper compounds resulted from the practice, initiated by French vine growers in the neighbourhood of Bordeaux, of spraying the ripening grape with mixtures of copper sulphate and lime, as a means of protection against losses occasioned by theft. It was later observed that vines treated in this way were remarkably free from disease, resulting in the use of Bordeaux miture as a fungicide.

Owing to its efficacy and simplicity, Bordeaux mixture is universally employed to combat disease, leaf diseases in particular.

But its universal adoption is not necessarily a guarantee of its superiority over other mixtures. Several mineral salts are highly toxic to the growth of fungi ; of these aluminium and nickel salts should be mentioned as comparing favourably with the toxicity of copper compounds, while lead and zinc salts are not always as effective.

The writer therefore suggests, in view of our present knowledge regarding the toxicity of aluminium and nickel ions in culture supplemented by experimental spraying that the use of a copper aluminium nickel sulphate mixture would be more effective in the control of leaf disease. The formula of the copper sulphate-lime mixture could be changed, say, from 5 lb. copper sulphate, 5 lb. lime to 2 lb. copper sulphate, 2 lb. aluminium sulphate and 1 lb. nickel sulphate, 5 lb. lime in 50 gallons of water.

The arsenic mixtures in the form of lime arsenite, lead-arsenate and copper aceto-arsenite (Paris green) have also been employed, but on a smaller scale than the copper and lime sulphur mixtures. The latter are also cheap and effective, their toxicity being dependent on many factors embodying the liberation of hydrogen sulphide and sulphur dioxide, the individual toxicity of the polysulphides and their conversion into thiosulphates.

Liver of sulphur, consisting of polysulphides of potassium, has similar properties, but its application entails an unwarranted expense. Colloidal and sublimed sulphur (flowers of,) and rosin sulphur mixtures should be exploited, although their toxicity is not always as marked as in the case of the lime sulphur mixtures.

It is suggested that a combination of lime arsenite and lime sulphur mixtures would be more effective than the arsenite or sulphur washes alone.

Apart from these mixtures, copper-lead acetate, lead acetate-copper, aceto arsenite and sodium borate should also receive consideration, while the use of sodium and calcium fluorides, the latter especially, should prove to be of great value in the future.

Other numerous instances of fungicidal mixtures, such as barium, sulpho carbonate, sodium ferrocyanide, strontium carbonate, etc., could be cited, but these are at present unsuitable for application on a large scale.

Returning to the original Bordeaux mixture, several modifications are now in use, known respectively as the Burgundy mixture, the Woburn Bordeaux and the Carbide Bordeaux mixtures.

The general formula of the Bordeaux mixture is the 5 : 5 : 50, which may be varied according to circumstance to include 8-2 : 8-2 : 50-40 mixtures. The 5 : 5 : 50 formula is made up of 5 lb. of copper sulphate, 5 lb. of best quickstone or burned lime to 50 gallons of water. The copper sulphate or blue-stone is first dissolved in 10 gallons of water in a wooden receptacle (metal-lined vessels are to be avoided, owing to interaction with the copper), while the lime is slacked by the addition of small quantities of water, the paste being stirred and subsequently diluted to 40 gallons. The copper sulphate solution is then poured slowly into the lime-water with vigorous stirring, a gelatinous suspension of copper hydroxide being obtained. At this point a drop of potassium ferrocyanide (yellow prussiate of potash), as in the case of the Bordeaux modifications, can be conveniently added. If a red colouration is produced, indicating the presence of free copper, more lime-water should be added till the uncombined copper has been converted into the hydroxide.

Excess of lime is, however, to be avoided, as the calcium of the lime retards the entrance of the copper ion into the fungus protoplasm, thus reducing its toxicity. The mixture is then ready for spraying.

In the preparation of Bordeaux mixtures, chalky and hard water should be previously softened by the addition of lime water. The carbon dioxide and bicarbonates which would otherwise precipitate the lime in the spray mixture, are thus deposited as chalk. The clear liquid is then run off to be used in the preparation of the wash. This is particularly important in Bordeaux mixtures with a low lime content.

The Burgundy or soda Bordeaux mixture necessitates the substitution of 8 to 10 lb. washing soda in place of the lime, the preparation being similar to ordinary Bordeaux. Recently French workers have suggested the use of sodium bicarbonate as producing a finer precipitate, with greater adhesive properties.

In Woburn Bordeaux, clear lime-water is used in place of milk of lime, while the quantities of copper sulphate and lime are appreciably less than in the original Bordeaux

Slake 1$\frac{3}{4}$ lb. of quicklime gradually and bring the whole up to 50 gallons of water with vigorous stirring; 25 gallons of clear lime water are run off, to which 2 lb. of copper sulphate dissolved in 1 gallon of water are added, the whole being brought up to 150 gallons. This preparation is very cheap and effective in regions of moderate rainfall, but it is doubtful whether its concentration is such as to weather the effects of heavy tropical rains.

In carbide Bordeaux, pure slaked lime is obtained by the action of calcium carbide on water, resulting in the generation of acetylene and the production of slaked lime. The proportions to be employed are embodied in the formula 5·4 copper sulphate; 3-2 lb. calcium carbide; 50 gallons of water.

At first 2 lb. of carbide are pulverised and slaked by sprinkling with water and made up to 40 gallons with water, to which 10 gallons containing 5 lb. dissolved copper sulphate are subsequently added. The advantage of such a preparation lies in the purity of the slaked lime, the difficulty of obtaining good quality burned lime thus being obviated.

Eau celeste is distinctly related to the Bordeaux mixtures, consisting of an ammoniacal solution of copper carbonate. It is made by adding 2 pints of strong ammonia (diluted to 26 deg. Baume scale) dissolved in 2 gallons of water to $\frac{1}{2}$ lb. of copper carbonate. The whole is stirred till solution is complete, and diluted to 50 gallons.

The evaporation of the ammonia produces a precipitate of copper (hydrate) on the leaves, after spraying.

As to which of the above mixtures is most suitable must be determined by local trials. In the long run the original Bordeaux and carbide Bordeaux will probably be the cheapest and most effective. Both mixtures contain

1 per cent. of copper (5 lb. of copper sulphate in 50 gallons of water,) which, allowing for "weathering" losses is sufficiently toxic to the growth of fungi; the 5 per cent. copper solutions can also be employed, but their effects will not be so lasting.

Small quantities of copper have been known to induce tackiness in rubber. The trees therefore should not be tapped at the date of spraying, or during the first two days of heavy rains. This consideration should be borne in mind, and requires further elucidation.

Turning to the arsenical compounds, the preparation of the lime arsenic, lead arsenate and copper-aceto arsenite mixtures should not present great difficulty.

In the lime arsenite mixture 2 lb. of lime are slaked gradually, and 1 lb. of white arsenic (As_2O_3) incorporated with the paste. After making up to 2 gallons with water, the whole is heated for half-an-hour in closed containers to avoid the danger of poisoning by arsenical fumes. After cooling, the mixture is then diluted to 100 gallons. This is a most effective wash, possessing insecticidal as well as fungicidal properties; the proportions of lime and arsenic can be increased when necessary.

The lead arsenate wash is finely granular, and can be made by dissolving 2 lb. of lead nitrate or lead acetate in 2 gallons of warm water in a wooden container, to which 1 gallon of water containing 1 lb. of sodium arsenate is added, the whole being brought up to 50 gallons while the copper-aceto arsenite wash is made by dissolving 1 lb. of Paris green in 50 gallons of water; the addition of ½ lb. of quicklime is also to be recommended.

Finally we are left with the preparation of the lime-sulphur mixtures. In the self-boiled mixtures 5 lb. of lime and 5 lb. of sulphur are used to make 50 gallons of spray. The lime is just covered with water in a barrel and the sulphur stirred in with the swelling mass of lime which is being selected, the barrel being covered to retain the heat. After a quarter-of-an-hour, with vigorous stirring at intervals, the paste can then be made up to 50 gallons of water.

In the boiled mixtures 5 lb. of sulphur and 5 lb. of lime are boiled in 10 gallons of water for an hour, water being added at intervals to replace loss by evaporation. The whole is then diluted to 50 gallons.

Sulphide mixtures are not stable in the presence of moisture, the sulphur being removed in the form of H_2S etc. These washes should therefore be used at once. Or 1 pint of glycerol or 1 lb. of soft soap should be added to the stock solution of 10 gallons to prevent decomposition, the whole being kept as airtight as possible.

It should always be borne in mind that these sulphide mixtures can also be prepared by heating together finely-powdered calcium sulphate (gypsum) and charcoal, thus obviating the cumbersome manipulation involved in boiling large quantities of water. Other cheap sources are to be found in the "black ash" residue (CaS) in the manufacture of sodium carbonate and the $Ca(SH)_2$ subsequently prepared from it by the Chance process.

The efficacy of these washes can always be increased by the addition of "spreaders" or adhesives. For this purpose 2 lb. of casein of soft soap should be added to 50 gallons of spray; 2 lb. of a cheap rosin dissolved in a gallon of water containing 2 lb. of washing soda and boiled for ten minutes before mixing with the wash also makes an excellent adhesive. Molasses are not always to be recommended owing to the solubility of the copper saccharate (in copper mixtures) which results in the scorching of the foliage.

Other adhesives have also been employed. These include silica gels, hard soap, wheat-flour (the gluten) kaolin, fuller's earth, vaseline waste, anthracene oil for lubrication, etc.

There can be no doubt that the operation of spraying would be considerably facilitated if the preparation of the washes could be reduced to the addition of the requisite quantity of water to a paste of standard composition. The unstable nature of such preparation often damps the enthusiasm of their would-be customers. But the addition of a little powdered Liebig's meat meal (used as a drier in ammonium sulphate, etc., to prevent deliquescence) and similar substances, and their storage in airtight containers should obviate difficulties of this nature.

Once the most suitable mixtures have been decided upon, then the preparation of such pastes will no doubt be of interest to manufacturers.

THE TECHNIQUE OF SPRAYING.

If it were possible, the trees should be sprayed several times a year. But this, it may be argued, is out of the question, a single spraying entailing great expense. It is, nevertheless, most important to apply the wash at the right time.

In order to cure disease you must avoid it. A wash, applied as the result of the badly diseased state of the leaves, cannot be expected to destroy the hyphae already in the tissues of the host. Only the superficial hyphae and reproductive organs (when they appear above the epidermis) are affected. If the wash is to be really effective, it should be applied three to six days after the trees are in full possession of their new leaves. Any alighting spores are thus prevented to a very great extent from damaging the foliage, the germ tubes being killed by the colloidal surface film present on the under and upper surfaces of the leaves.

Buller has found that the edible mushroom can discharge about a million spores a minute for at least two days. The importance of suppressing spore germination is thus obvious.

Statistics as to the actual costs of spraying and the quantities to be employed will not be available until extensive field trials have been made. The former will naturally vary with the wash employed and the formulae adopted, while in the case of the latter an average allowance of two gallons per tree, dispersed as a fine mist, in the upper and lower branches would achieve better results than leaving the trees to throw off the disease by their own unaided efforts.

It should be possible to construct a disease map for each estate, by noting those areas in which diseases tend to be more prevalent than in others. Everyone on the spot should be able to recognise the symptoms of the several leaf diseases and report on them at once. Such a procedure would considerably facilitate the subsequent operation of a spraying campaign.

In the case of a sudden localised outbreak of a serious nature, the affected trees should be sprayed at once and the neighbouring healthy trees within a radius of 50 to 100 yards. The trees should be kept under observation and sprayed a second time if necessary.

When relatively large blocks are affected, the estate is faced with the option of immediate spraying or the possibility of complete devastation.

Up till now it has not been necessary to spray for the Rim blights and Leaf spots of Hevea; but this does not imply that they need not be kept under observation. The sooty moulds should be destroyed with a lime arsenite mixture, if their recurrence is a constant feature; though not parasitic on the leaves they nevertheless lower the vitality of the tree, the photosynthetic activity being reduced by the occlusion of the light.

The Thread blights should be destroyed by similar treatment.

With regard to the leaf fall fungi, namely Oidium, Phytophthora and Glœosporium, prompt measures of control should be adopted the moment the disease appears. If these fungi are taken in hand in the very beginning, it is possible to reduce the disease incidence to a minimum. If, however, they are allowed to luxuriate unchecked, capital and labour which might have been saved by prompt action will eventually have to be expended. Oidium is not as serious as Phytophthora and Glœosporium, owing to its superficial nature; it can be combated by a lime sulphur or lime arsenite wash. The latter on the other hand n t only penetrate the interior of the leaves, but also grow down the leaf and fruit stalks into the young branches. Their first appearance should be dealt with by an application of a copper or sulphur mixture, and the affected zone kept under strict observation. During wintering, all dead twigs and fruits capable of harbouring the hyphæ must be removed, and the trees sprayed again within a week of producing fresh leaves. On some estates the fruits have been removed, prior to the beginning of the rains, thus removing the main sources of infection, but such a procedure does not always justify the expense, owing to the difficulty of removing all the fruits.

In the spraying of small areas, the trees should receive from 5 to 10 gallons of spray each up to the age of 5, and all over 5 years from 10-20 gallons. Where large blocks of rubber are concerned, these approximations would have to be considerably reduced. In the latter case estate labour could not be spared for such an object, and the spraying would have to be carried out on the contract system.

SPRAYING BATTERIES.

As research proceeds in this direction, every estate will, it is hoped, come to possess its own spraying battery. As to the actual form this battery will take it is at present too early to surmise. It is unlikely, however, that power sprayers will be used, owing to the intervention of such factors as lie of the land, etc. Knapsack sprayers, of the air pressure type, from which the spray is delivered as a fine mist by the operation of internal pressure, will probably be employed, the sprayers being lined with a non-corrosive material (such as lead, etc.), their capacity being limited to three to four gallons. Supply tanks on wheels will have to be drawn to the various parts of an estate, to enable the operators to recharge the sprayers. Pumping engines from the base to the seat of operations are out of the question.

Finally, owing to the difficulties obtaining in spraying the crowns of the trees, a system of rope ladders or "ladder-stands" may have to be perfected.

A suggested type of "ladder-stand" would take the form of a modified fire escape ladder, consisting of a series of ladders rising one above the other, with rungs at intervals of two feet. The framework of the ladders should be made of iron-wood or other hard woods, but the supports represented by the stepless half of an ordinary ladder would have to be made of hollow metal joints, transverse connections being maintained with the other half of ladder series. In this way, the operator could deliver his spray from the necessary altitude, dispensing it as a fine mist among the crowns.

If work of this nature is carried out now, a greater saving will be effected in the future, and estates will be able to cope with the disease factor on an economic basis. Few difficulties are insurmountable once they are grappled with in the right way, and everyone concerned with the plantation industry should give serious consideration to the question of the control of leaf disease. It must be faced sooner or later, and there is no time like the present, especially when problems of this nature have to be confronted. More mycologists and chemists must be employed now, and a greater stimulus given to experimental spraying on a large scale.—The India-Rubber Journal, Vol. LXX, Nos. 23 and 26.

CONTOUR TERRACING IN HEVEA PLANTING.

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In the early days of the rubber planting industry in East India, plantations were universally laid out in geometrical patterns and the trees were planted in straight rows regardless of land contour, the principal idea being to so lay out the blocks that control of tapping tasks would be facilitated for the inspector. The result was that while the trees stood in beautifully straight lines, easy of inspection the task of the tapping coolies was rendered extremely difficult, as any given row of trees did not occupy the same contour level, thus compelling the cooly to climb from tree to tree for the purpose of tapping and collecting. Furthermore the trees were set out on the hill sides without any provision for soil or moisture conservation, with the result that flood waters washed away the top soil, leaving the ground barren of humus, liable to erosion during torrents and to baking during the dry spells. As the trees reached maturity the roots became exposed and many acres of good rubber trees were lost as a consequence, to say nothing of the lower yields due to the drying out of the soil.

Planters gradually awoke to the necessity of conserving the soil and dams were built about the trees, at excessive cost, in a vain endeavour to retain the soil, the valuable portions of which had already washed away to the valleys to clog the lower reaches of the streams. By the methods