The Pathology of Fungal Leaf Pathogens of the Genus Eucalyptus

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Certain principles of plant pathology have particular application in a consideration of the fungal leaf pathogens of the eucalypts. The application of these principles is conditioned by certain characteristics of eucalypts and eucalypt forests.

PURE AND MIXED STANDS

Eucalypt forests typically consist of mixed stands of two or more species, each from a separate sub genus e.g. Macrantherae and Renantherae or Macrantherae, Renantherae and Eudesmiae. (Pryor 1959). The individual species making up a stand have genetical isolation from the species of other subgenera, but interbreed at stand margins with other species of the same sub genus. The establishment of pure stands of individual eucalypt species in general introduces and increased risk of disease on an ephiphytotic scale because of reduced variation in species composition of the stand.

GENETICAL VARIABILITY

There is good evidence that eucalypts are out-breeding species (Pryor personal communication). It is true that viable seed may be raised from self-pollination. The progeny of such crosses are usually relatively weak in competion with out crossed progeny. This means that in natural stands of eucalypts of a particular species, the degree of genetic variability of the population is high. If at some stage it appeared desirable to vegetatively propagate a particular eucalypt phenotype because of desirable characteristics which it manifests, this would introduce a considerably increased risk of disease. The conversion of a normally outbreeding species to a single vegetatively propagated clone, is the extreme

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case of reduction of genetic variability. The conversion of either an inbreeding species to a single vegetatively propagated clone, or an outbreeding species to a number of lines produced by controlled fertilization a seed garden of certain selected genotypes, are intermediate degrees of reduction of genetic variability. The degree of reduction of genetic variability in the host stand has considerable significance in pathology.

The cereal crops demonstrate that reduced genetic variability of the host crop results, over a relatively brief period, in the local build up of the strain of the pathogen best adapted to parasitise that particular host strain, i.e., the number of plants which «escape» the disease by chance in the particular area is reduced. With long rotation crops, such as forests, the probability of build up of adapted strains of pathogens is very high because of the number of generations the pathogen goes through in the life cycle of the crop, and the relatively high mutation rates, shown for the fungi which have been investigated.

It is true from an applied viewpoint that the elite vegetatively propagated stand may give a higher yield per unit area than a stand of high genetic variability per unit area despite the higher degree of inci dence of disease in the former. This is merely a matter of the overall significance of the parasitism of the pathogen. Certain eucalypt leaf pathogens, e.g. powdery mildew are potentially serious parasites from a growth and yield viewpoint and on stands of vegetatively propagated clones, which have not been selected with an eye to true resistance as distinct from «disease escape» (i.e. field resistance), ephiphytotics can be expected.

EVERGREEN NATURE OF THE HOST

The evergreen nature of all eucalypts has considerable significance in certain pathological considerations.

Many fungal leaf parasites of deciduous trees normally produce two distinct morphological forms e.g. Tar spot of Maple. The imperfect stage fruits on the living or dying leaves on the tree, and the perfect stage is produced on the fallen leaves or twigs on the ground. The carry-over of innoculum from season to season in the fallen leaves is the weak point in the life cycle. The application of pre-leaf fall sprays which penetrate the leaf e.g. the organic mercurial fungicides, effectively prevents the development of the perfect stage on the leaves when they fall to the ground. This breaks the life cycle and achieves very satisfactory control (Hutton 1954). On evergreen species there is a production of the imperfect stage of the fungal leaf pathogen throughout the year and conidia are available for further leaf infection whenever environmental conditions are satisfactory.

The evergreen nature of the host is also significant with those pathogens which typically produce «latent infections» of the host plant (Simmonds 1941). These organisms infect the host leaf and lie dormant forwaring periods of from 3-12 months in the sub stomatal chamber or sub cuticular area. This period of relative dormancy is followed by extensive colonization and fruiting of the organism. Typically the organism produces the imperfect stage at this fruiting. The perfect form of the pathogen, if it is produced, is formed when the leaves are shed and subjected to alternate periods of wetting and drying on the ground (Kelly 1948).

In the case of an evergreen host this type of cycle means that spores of either the perfect or imperfect form are available for host leaf infection at any time in the year when environmental conditions are satisfactory.

BLOOM AND CUTICLE THICKNESS OF EUCALYPT LEAVES

The young leaves of many eucalypts are typically covered with bloom and if grown in high light intensities have thick cuticles. These factors are very effective barriers to infection by many fungal leaf pathogens. They are more in the nature of «disease escape» mechanisms than true resistance mechanisms because the hosts can be artificially infected if the leaves are kept in a saturated atmosphere for 24-48 hours. This breakdown of normally satisfactory barriers to infection in the field can be seen on certain eucalypts e.g. *E. dalrympleana*, where these species grow in areas of frequent fogs or high humidity for long periods. Under normal conditions drops of spore suspension of the pathogen fail to wet the bloom covered leaf and roll off carrying the spores with them. If the leaves are pre-treated in a saturated atmosphere drops containing spores do wet the leaves and deposit the dissemules on them.

As the leaf ages the bloom disappears and the cuticle is broken by insect and mechanical wounding. At this stage the leaves are readily wet by a spore suspension and the barrier to infection is not nearly as effective. The wounds provide points of entry for leaf pathogens. In addition these wounds are a reservoir of food for many weak facultative parasitic leaf pathogens. These organisms can often readily infect a leaf if a food base external to the spore is supplied (Brown 1955). It has been suggested that supplying such a food base increased the «innoculum potential» of a spore or spore load in certain root deseases (Garrett 1956). The same is possibly true of leaf pathogens. Many of the wounds on eucalypt leaves are microscopic in size. It is very unusual to find a series of sections of eucalypt leaf over 6 months old which do not contain a number of such wounds.

ABILITY OF THE EUCALYPTS TO REJUVENATE THEIR CROWNS AFTER DAMAGE

The eucalypts have remarkable ability to produce new crowns when they are fully or partialy defoliated. As a consequence damage to the crowns is generally of less significance in productivity of eucalypts than with some other trees which do not possess the same faculty for crown rejuvenation. However partial or full defoliation of even a mature eucalypt will often result in the production of shoots on the main bole from dormant buds. These shoots with their developed trachery systems cause knots and defects in what would otherwise be clear timber. Successive defoliations result in large knots and burls which can quite often reduce the value of the product manufactured from such trees.

NECROGENIC REACTIONS

Plants which are hypersensitive in their necrogenic reactions to biotrophs or their metabolites are resistant to further invasion by the reproduction of the biotroph pathogen (White 1957, Mueller 1940). This hypersensitive necrogenic reaction is a defence mechanism which has been defined as a hyperergic necrogenous reaction (Gaumann 1950). By contrast necrotrophs successfully invade living tissue generally by killing the host cells in advance of penetration (White 1957). In the case of these organisms or their metabolites a host which is hypersensitive in its necrogenic reaction is susceptible to invasion by pathogen. The pathogen reproduces on the dying or dead host tissue and the host is said to be susceptible to the disease.

Oidium (*eucalypti?*) is an example of a pathogenic biotroph which is very severe in its parasitism of seedlings of a great variety of eucalypts. This applies particularly to eucalypts from the drier areas of Australia when these are raised in glass houses or planted in humid environmental conditions. Certain other eucalypts e.g. *E. diversicolor*, which are not dry country species are also very susceptible to this disease of powdery mildew in the seedling stage. Many examinations have been made of susceptible seedlings but so far no example has been found of a variety which gives the desirable hypersensitive necrotic reaction when infected with the pathogen.

This line of investigation justifies further work because this disease will kill 1 foot high seedlings of susceptible species under humid conditions.

Septoria blotch is a common disease of eucalypt seedlings particularly some Macrantherae, although it also causes blotching of older leaves. In this case the pathogen is a necrotroph of he genus *Septoria.* In this case research is necessary to find a host variety which is hyposensitive in its necrogenic reaction to the pathogen. It appears from work already in hand that such a resistant variety will be easier to find in this case.

No species of rust (a biotroph) as so far been recorded on eucalypts in Australia. There is a record of *Puccinia psidii* on *E. melliodora* in Brazil. (Joffily 1944, Da Silva 1939). Once again in such a case research should be concentrated on finding a variety of the host species which gives a hypersensitive necrogenic reaction when infected.

HISTOGENIC DEFENCE REACTIONS

It is possible that wound cork formation may be of little significance in defence, the barrier merely being a monument which records that host and pathogen met on this battlefield (Brown 1955). There is evidence, however, that in certain plants the formation of a vivotoxin which is actively antibiotic to the pathogen does accompany wound cork formation (Mueller 1957).

Wound cork barriers are of common occurrence in eucalypt leaves. Two distinct histological types of wound cork can be recognised. In the first type the barrier forms at the margin of the lesion and cuts through the leaf from surface to surface completely surrounding the necrosed area. This type of barrier accompanies leaf spots caused by *Coniothyrium* sp. on *E. grandis.* (See Plate 1).

The second type of barrier is saucer shaped and cuts through the centre of the leaf tissue reaching only one surface of the leaf and on this surface surrounding the necrotic area i.e. neither the necrosed area nor the barrier extends through the leaf from surface to surface. (See Plate 1). This type of reaction has been commonly observed on varieties of certain Renantherous eucalypts infected with the pathogen *Pseudo septoria* n.sp. Not all varieties of these particular Renantherae show this type of host reaction. In some cases wound cork extends from surface to surface with this pathogen. The saucer-type reaction is probably indicative of a higher degree of resistance to the pathogen by the particular host variety and these varieties would appear to be best selected for any plantation projects.

Note all localised lesions on eucalypt leaves have cork barriers of the above types. Spots caused by pathogens of the genus *Septoria* and *Phaeoseptoria* have no wound cork barriers on the margin, this is a common experience with certain leaf pathogens (Cunningham 1928). In this case resistant varities will be those which are hyposensitive in their necrogenic reaction to infection by the pathogen.

Certain leaf spotting pathogens e.g. *Pestalotia* and *Phoma* are associated with wounding either by insects or mechanical agencies. Artificial inoculation with these organisms has only been satisfactory in establishing infections, on young healthy leaves, when the leaves were wounded prior to inoculation. In these cases the selection of varieties of various eucalypt species which have particularly thick cuticles, which resist abrasion and puncturing are likely to show field resistance. Alternatively, the protection of crops of non-resistant varieties with conventional or systemic insecticides may be satisfactory.

EFFECT ON HOST PHYSIOLOGY

Leaf spotting pathogens reduce the active photosynthetic leaf area. The significance of this leaf area dimunition in a reduction of growth rate will depend to some degree on the proportion of the leaf area destroyed, the significance of the type of leaf area destroyed in the total photosynthetic activity of the crown, and limits set by environmental factors particularly light intensity.

Pathogens which are most likely to have serious effects on photosynthetic activity are those which parasitise young active leaves. *Oidium* sp. and *Septoria* sp. are very active on this class of leaf. By contrast the «latent infection» type of pathogen e.g. *Guignardia citricarpa* (Kiely), or the wound infection type e.g. *Pestalotia* sp. only become actively parasitic when the leaf is physiologically «ripe» for colonization. This is normally when the leaf is reaching the end of its active photosynthetic life. From this viewpoint *Oidium* sp. and *Septoria* sp. are much more likely to be serious causes of loss of increment. There is of course the possibility that infection by «latent infection» and «wound type», relatively weak parasites, actually shortens the active life of the individual infected leaf. In general it is unusual to find healthy leaves over 18 months old on eucalypts in Australia.

Septoria n. sp. causes a rise in the night transpiration of infected leaves of *E. dalrympleana*, by comparison with that of uninfected controls. This is in agreement with findings of the effect of some other leaf pathogens on the transpiration of cereals (Yarwood 1947). Where eucalypts are growing in areas of limited moisture availability this increased water loss could be a significant factor in the health and vigour of the crop.

TAXONOMY

Records of the fungi occurring on the leaves of the genus Eucalyptus are available from the following sources:

In most cases little or no work has been done to establish whether these organisms, normally regarded as leaf pathogens, are actually parasitic in their occurrence on the genus Eucalyptus. This is a field for considerable investigation.

The physiology of these fungi is also worthy of research work. Many of these organisms are primary colonisers of eucalypt leaf tissue whether living or recently dead. Such leaf tissue is a relatively resistant material from a decay viewpoint. Studies on the physiology of these primary colonisers would be of value in understanding the decay and humification cycle of such materials.

INTRODUCTION OF THE EUCALYPTS TO AREAS OUTSIDE AUSTRALIA

The fungal leaf pathogens of the eucalypts are worthy of consideration from a quarantine viewpoint. The facultative parasites, the group of organisms most frequently found fruiting on eucalypt leaf tissue, are probably of little significance. These organisms are likely to have a wide host range. It is probably that leaf pathogens of this group, which are native to the countries into which the eucalypts are introduced, will eventually parasitise eucalypt leaves. Consequently, regulations aimed at keeping out species of these pathogens which occur on eucalypts in Australia are probably unnecessary.

The facultative saprophytes and near obligate or obligate parasites are likely to have a much more restricted host range. It is likely that where pathogens of this group parasitise eucalypt leaves the organisms are worthy of at least sub specific or variety taxonomic ranking. Regulations, to prevent the introduction of such organisms, either from Australia or elsewhere into countries, where eucalypt establishment is envisaged, are very desirable.

There is no evidence that any fungal leaf pathogen of the eucalypts is seed borne. Consequently, regulations which prohibit the introduction of vegetative eucalypt material should be quite satisfactory.

There is evidence that some eucalypt leaf pathogens are associated with insect damage. No work has been carried out on the significance of this association. It is hence safer at present to prohibit the introduction of insects which parasitise or breed on eucalypt leaves until more information is available on fungal-insect association.

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LA PATHOLOGIE DES PATHOGÈNES FONGUEUX DE FEUILLES DU GENRE *EUCALYPTUS*

Résumé

Certains principes de la pathologie des plantes ont une application spéciale en ce qui concerne les pathogènes fongueux des feuilles. L'application de ces principes dépend de certains caractéristiques de l'eucalyptus et des forêts de l'espèce. Les cultures de peuplements pûrs de quelques espèces d'eucalyptus introduisent généralement un risque plus grand de maladies sur une échelle épipytique, à cause de la possibilité réduite de variation des espèces composant ces peuplements.

LA PATOLOGÍA DE LOS HONGOS PATÓGENOS DEL GÉNERO *EUCALYPTUS*

Resumen

Ciertos principios de la patología de las plantas tienen una aplicación especial en lo que se refiere a los hongos patógenos de las hojas. La aplicación de estos principios depende de ciertas características del eucalipto y de los bosques de la especie. Los cultivos de poblaciones puras de algunas especies, introducen generalmente, un riesgo mayor de enfermedades sobre una escala epifítica, a causa de la reducida posibilidad de variación de las especies componentes de esas poblaciones.

A PATOLOGIA DOS FUNGOS PATÓGENOS DO GÊNERO *EUCALYPTUS*

Resumo

Certos princípios da patologia das plantas têm uma aplicação especial no que diz respeito aos fungos patógenos das fôlhas. A aplicação dêsses princípios depende de certas característicaß do eucalipto e das florestas da espécie. As culturas de povoamentos puros de algumas espécies introduzem geralmente um risco maior de doenças sôbre uma escala epifítica, por causa da reduzida possibilidade de variação das espécies componentes dêsses povoamentos.