A GANODERMA ROOT ROT OF CITRUS.

By F. W. BLACKFORD, M.Sc.Agr., Assistant Research Officer, Plant Pathology Section, Division of Plant Industry (Research).

In September, 1942, an unusual root rot of citrus trees was reported from the Gayndah district by Mr. A. W. S. May, Assistant Research Officer. As the root specimens submitted exhibited symptoms not encountered previously in the field or described in literature discussing citrus diseases, an investigation of the cause of the rot was undertaken.

The disease was found on examination of the orchard concerned to occur in a compact group of ten trees of the Beauty of Glen Retreat variety of mandarin budded on rough lemon stock. One tree had been killed and had been uprooted and removed from the orchard some time prior to the writer's first visit to the property. The tops of the other trees exhibited the symptoms usually associated with root rot in varying degrees of severity. Leaves were chlorotic and were being shed and the fruit were small and prematurely coloured. Twigs were dying back, the dieback extending into the larger limbs and so affecting the greater part of the tree. In a few cases, single limbs on trees had not been affected and were bearing normal foliage and fruit. It was found later that such limbs were being supported by a small part of the root system as yet unaffected by the rot. In the case of the tree which had been killed by the disease, every main root was found to be affected by the rot.

The most striking and characteristic symptoms were found on affected roots. The soil, which is of a very sandy type, was tightly encrusted round affected roots of all sizes—from the smallest it was possible to find up to main roots, three inches or more in diameter—and even, in some cases, round the crown and trunk of the stock. The wood and bark exhibited a dry, crumbly rot, and if the sand-encrusted bark were lifted it broke away, leaving a buff-coloured, furry growth of fungous mycelium on the cortex of the root.

Specimens of affected roots were collected and placed in stoppered glass tubes to ensure safety in transit. When examined in Brisbane three days later, the tubes were found to be almost filled with a profuse growth of white fungous mycelium. The fungus was easily isolated from such material in pure culture on potato dextrose agar. No spores were formed but the mycelium was typical of that of a member of the Basidiomycetes. Root specimens taken from the tree which had been uprooted failed to produce any growth of fungous mycelium when pieces were plated on the agar medium, and it is quite probable that the fungus had been killed by exposure to the sun and air.

Fruiting bodies commenced to appear on the stock of an affected tree in January, 1943, after a period of very wet weather, and in March well-developed sporophores were abundant. Several stalked sporophores had been produced from the broken ends of roots left in the soil when the orchardist had uprooted the dead tree mentioned previously, and another tree which was very severely

affected by the root rot had developed several sporophores in the form of brackets growing out from the trunk of the stock (Plate 1).

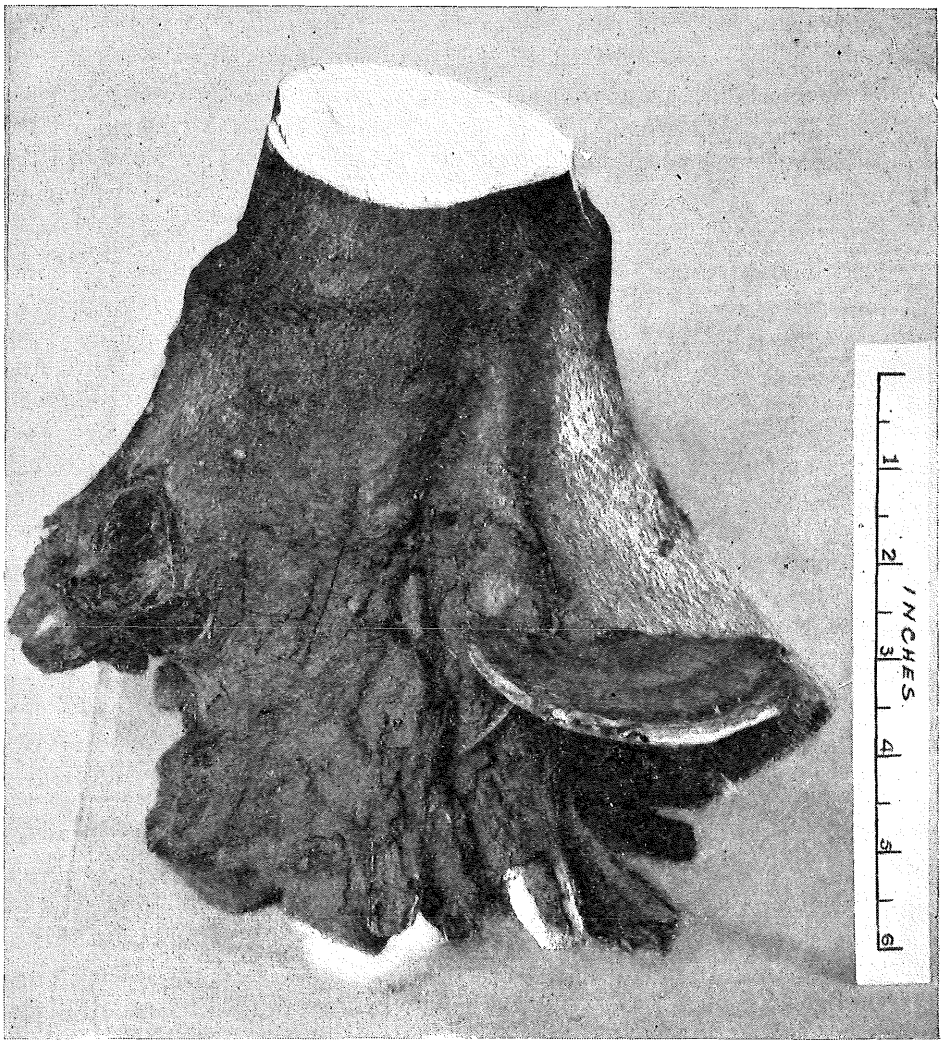

Plate 1.
Butt of a severely affected citrus tree showing a *Ganoderma lucidum* bracket.

The sporophores of the causal fungus are striking in appearance. In most cases they are stalked and, where two or more occur close together, the pilei may fuse. Grass shoots, twigs, leaves, etc., are often found enclosed by the growing tissue of the sporophores. At first they are soft and rubbery, with a dark-brown, polished stalk and a creamy-white, knob-like pileus. As the pileus enlarges, a light-brown, varnish-like colour develops on the upper surface. Later as the sporophores age, harden and become corky, this shining, varnished appearance covers the whole of the upper surface, the under surface remaining

creamy-white (Plate 2). The brown, verrucose, truncate-oval spores are borne in tubes opening on the under surface of the pileus. The range of measurements of fifty of these spores was $10 - 11\ \mu$ x $6{\cdot}5 - 8\ \mu$. The fungus has been identified as *Ganoderma lucidum* (Leyss.) Karst.

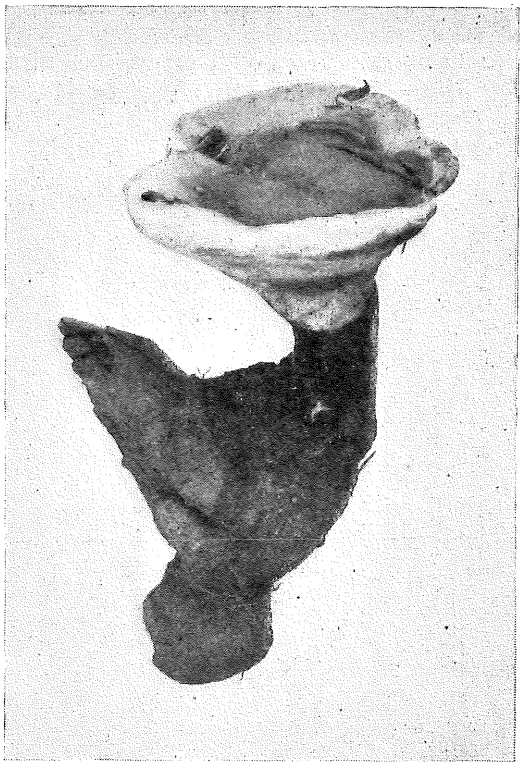

Plate 2.
Mature *Ganoderma lucidum* sporophore from a citrus root.

In the same group of affected trees, a bunch of fused sporophores similar to those found on the broken ends of the roots of the dead citrus tree was discovered in March, 1943, half-way between two citrus trees without any apparent connexion with citrus tree roots. By carefully digging round the base of these sporophores it was found that a solid, cylindrical core of sandy soil, tightly bound together by mycelium, extended to a depth of 18 inches below the surface of the soil, and that it originated from a dead native tree root about 4 inches in diameter (Plate 3).

This root was traced back to an old stump which had merely been burned off below plough depth when the land was cleared. The sapwood of the stump and all of its roots was dry, cream-coloured and crumbly as a consequence of the rot which had developed from the invasion of the tissues by the fungus. The true wood did not seem to be affected by the fungus, but later

it was found that it could be attacked, although the subsequent rot progressed very slowly. From a comparison of the sporophores, spores and mycelium on potato dextrose agar, the fungus affecting this native tree root was identified as being the same as that attacking the citrus roots. Further digging to remove the stump and its roots showed that the roots of affected citrus trees had come into contact with the rotted roots of the stump, the fungus thereby gaining entrance to the citrus roots. This contact seemed to be necessary for infection to take place because, although the roots of the stump passed close to one citrus tree within the group of affected trees without actually making contact with its roots, this tree remained healthy.

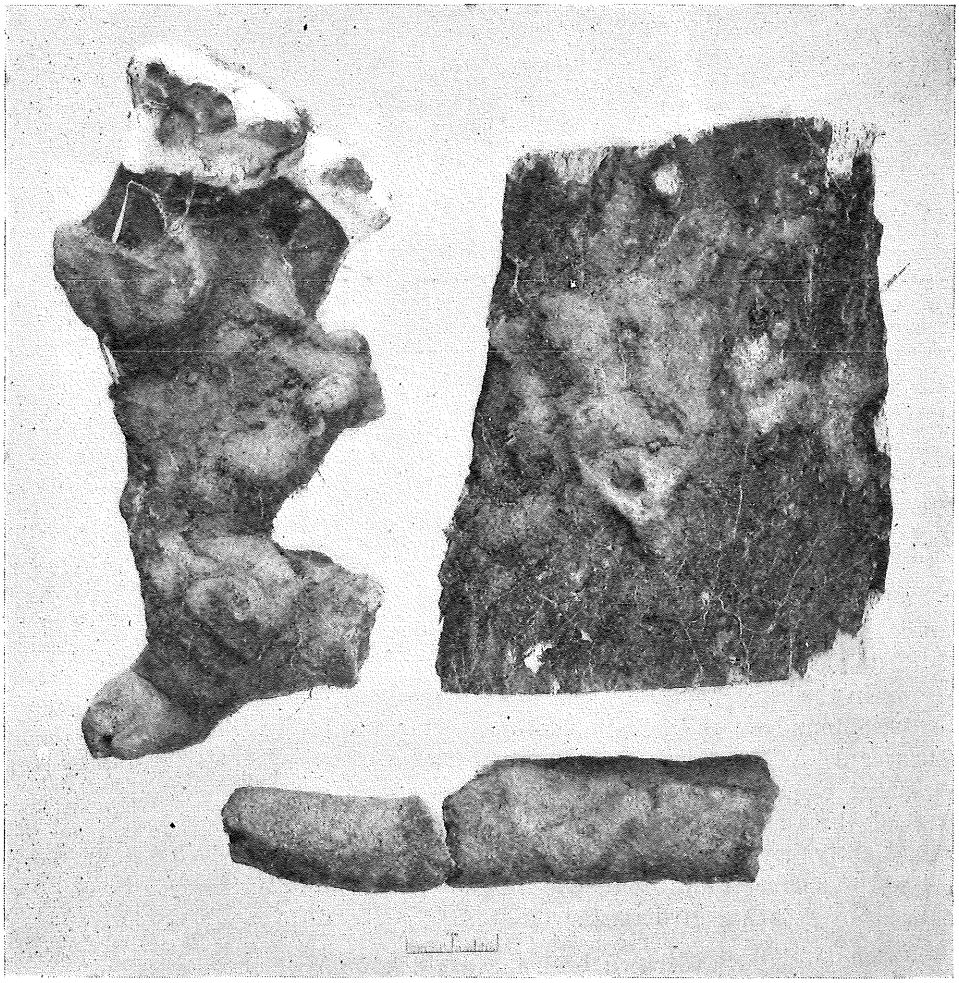

Plate 3.

Left hand figure shows young composite sphorophore of *Ganoderma lucidum*. Right hand figure shows point of origin of sporophore on *Eucalyptus paniculata* (?) root. Lower figure shows core of mycelium and soil which connected the sporophore with the root.

Owing to the absence of aerial parts of the native tree, a definite identification of the stump is impossible, but the specific range of trees growing in the vicinity of the orchard and comments by the Division of Forest Products of the Council for Scientific and Industrial Research, by whom a specimen of the root was examined, warrant it being identified as probably *Eucalyptus paniculata* Sm., i.e. the grey ironbark. Two more cases of the death of citrus trees in other orchards, one of Washington Navel oranges on lemon stock and another of Ellendale Beauty mandarins on orange stock, due to the same fungus, have been observed more recently and in each case well-developed sporophores were obtained. In the former case, the native tree host of the fungus has been identified as probably *Eucalyptus gummifera* (Gaertn.) Hochr., the red bloodwood, and in the latter as probably *E. tessellaris* F. v. M., i.e., the Moreton Bay ash or Carbeen. These identifications are uncertain because only roots were available. On the orchard on which the Moreton Bay ash was believed to be the native host tree, plants of the tar vine, *Boerhaavia diffusa* Linn., growing adjacent to the affected trees—which were only two to three years old and had been killed by the root rot—had also been attacked at the root with consequential extensive rotting.

As the most important consideration in this outbreak of root rotting—from the orchardist's point of view—was eradication, the sources of infection were eliminated as completely as possible, all dead and severely affected citrus trees with their rotted roots being dug out and destroyed. The soil was removed from the butts of slightly-affected trees, which were surgically treated to eliminate all affected roots and parts of the butt, and the exposed surfaces were treated with Bordeaux paint or lime sulphur used at a strength of 1 in 6. The butt and roots were left exposed to the sun during the warmer months of the year in an attempt to kill out any fungous mycelium which might have been left behind after the described treatment had been applied. Orchardists were advised not to replant infected areas for at least three years after attacked trees had been removed, it being hoped that the lapse of this period will allow the fungus to die out.