We now have everything except the plan and operation by the growers and shippers to stop the price cutting competitive duel that goes on in which process we growers pay the bill.

In behalf of the growers and shippers of avocados and limes in Florida, may I commend the Florida State Horticultural Society for this and all the years previous scientific study and addition to agricultural knowledge of not only our commodities, but all agriculture in the state. I don't believe the average person realizes the far reaching good that has been accomplished.

The consuming public must now realize that vegetables and fruits from Florida are "GENUINE" as to integrity of sizes, grades, maturity and quality.

CLITOCYBE ROT OF LYCHEE TREES*

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The bible of the lychee grower is G. W. Groff's Book, "The Lychee and the Lungan" (1). In this book which describes the extensive experience of the Chinese in growing lychees, the most serious diseases mentioned are some "undetermined leaf spots". Groff quotes Reinking, a well known plant pathologist, as saying: "The lychee tree is remarkably free from all injurious fungus attacks". During the early years of the cultivation of the lychee in Florida the statement described the situation very well, since the few lychee trees in the state showed little sign of being affected by any disease.

Truly disease-free crops are very rare indeed, however, and as any plant is grown more intensively, new and previously unknown diseases can be expected to appear. This truth is one of the best reasons for any region to strive to avoid specializing too much in growing one single agricultural product, a principle which is now evident to the citrus industry.

In the case of the lychee, the most important disease which has appeared on the horizon is mushroom root rot caused by the fungus *Clitocybe tabescens (Fr.) Bres.* It is the purpose of this paper to describe what has been learned about the condition and to try to evaluate its importance for the growing lychee industry.

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DESCRIPTION OF CLITOCYBE TABESCENS

Clitocybe tabescens, like its closely related fellow-parasite *Armillaria mellea,* is a fungus which is widely distributed and has been found to attack many different kinds of plants. Its effects are especially severe on fruit trees of many kinds but it also attacks many other woody plants including Australian pines (Casuarina spp), oaks, and even some herbaceous types like banana plants (4). Characteristically, this pathogen attacks a wounded root and makes its way as a sheet of white or cream-colored fungus material between the bark and wood of the affected tree.

The fungus may exist in the roots for many years in its vegetative form only, as a layer of fungus mycelium. Eventually however, a fruiting structure is formed. This consists of a clump of mushrooms, each with gills on the underside of the cap like the pages of a book (Fig. 1, 2). These gills are not confined to the cap but extend part way down the stem.

The gill surfaces produce millions of spores which are disseminated over a wide area by wind currents. Each of these spores theoretically can produce a new fungus colony and a new infection, but in nature new infections generally appear after contact with an old infected root.

Although *Clitocybe tabescens* is found in the ground, it is not a true soil fungus. It grows only on roots or plant debris and not in the soil itself. When the roots which it infects have been consumed, Clitocybe itself disappears from the soil. However, many years may elapse before this occurs.

Mushroom root rot is often very spectacular in its effects. Trees attacked by it may look normal and healthy at one time and yet be

Fig. 1. Fruiting bodies of Clitocybe tabescens on a laurel oak.

completely dead a few weeks later. This does not mean that the fungus acts quickly or grows quickly. What has happened in these cases is that Clitocybe has been growing for a long time, perhaps years, in the cambial area of the root and crown of the tree but shows its effects only when it has finally girdled the tree completely. At this time the visible deterioration of the tree begins.

Clitocybe On Other Hosts

Different host species vary in their susceptibility to the disease, but it may be possible to see a general pattern of action of this fungus if its behavior is examined on a number of hosts. Peach trees are among the most susceptible of the known hosts of Clitocybe. Thornton (6) described a 3½ year old orchard in which 38 per cent of the trees were infected by this fungus. The orchard was planted on land which had originally contained many blackjack oaks (*Quercus laevis*). It was later abandoned. However, Thornton has since planted several other peach orchards (7) including some on land which contained blackjack oaks, and has found that the new trees have been attacked only "in very occasional instances", without any indication of spread of the disease.

Fig. 2. Mushrooms of Clitocybe tabescens. Notice that gills are continuous with the stem.

Tung (*Aleurites fordii*) trees also are susceptible to mushroom root rot. Damage is often seen on young trees within a few years of planting. West (8) recommended that soil of tree spaces from which such young diseased trees were removed be treated with a drench consisting of 2 per cent commercial formalin. Large (2) observed that death occurred only in isolated tung trees although he considered the fungus potentially a serious problem.

Clitocybe rot has been very severe on all species of Australian pine (Casuarina spp). Rhoads (5) studied a large windbreak planting on 3 sides of a citrus grove at Georgiana, Merritt Island, Florida. The study began when the trees were eighteen months old. During the following ten years, 77 per cent of the 263 trees on the north side of the grove died. Twenty-seven of 29 replant trees set in the windbreak about 6 months after the study began also were killed by the fungus. In this case, the disease spread from a number of centers, and each year additional trees were found to have been killed. Since these trees were less than 10 feet apart, root contact between them was very likely, especially in the later years of the study. It is interesting however that the Australian pine windbreak plantings on the east and west sides of the grove did not show such a severe mortality and most trees in those locations survived during the period of this study.

Rhoads (3) in 1942 described conditions in a small nursery at Artesia, which had been

under his observation for a period of more than ten years. During this time, he found a number of new hosts of *Clitocybe tabescens* in the nursery, including banana (Musa spp), sapodilla (*Achras zapota*), hibiscus (*Hibiscus rosa-sinensis*), rose-apple (*Eugenia jambos*) and, according to the owner's report, lychee (*Litchi chinensis*). Some plants of the first three species mentioned were killed. The owner cut away the infected portions of the rose-apple and lychee which had not been too drastically attacked.

I was able to visit this site in October 1955 and found that representatives of each of the species named above were still alive, including the two trees which had been surgically treated – the rose-apple and the lychee. These trees, incidentally, are now more than 30 years old. I saw no evidence of the presence of Clitocybe anywhere in the nursery. This area was first cleared and planted about 1923. Mushroom root rot was prevalent in certain places in the nursery for more than 15 years after that time, but at present it does not seem to be active at this location.

Here is a case where Clitocybe rot is no longer important, after being a problem for a period of years, even though additional susceptible trees are still present. How can this have happened? Any explanation must be hypothetical in the absence of a detailed investigation, but it seems likely that many of the infected roots and their parasitizing Clitocybe fungus have disintegrated in the soil. Clitocybe travels mainly in infected roots and, in the absence of good root contact under proper conditions, it will die out in place and disappear. This can explain not only the events in the Artesia nursery, but also the fact that the Clitocybe problem is usually most serious during the first years after land has been cleared.

Clitocybe On Lychees

Clitocybe rot has been found on lychee trees on both the east and west coasts of Florida. It has killed about 25 trees in one grove on Merritt Island, and numerous young trees in the Sarasota area. It is also present in Pinellas county and has been reported by growers from a number of other counties.

The planting at Merritt Island is especially significant. It contains about 325 trees planted in 1947 and is one of the older commercial groves of Florida. This grove was set on land from which oaks and pines had been cleared just previous to planting, a situation common in most agricultural areas of Florida. By August 1955 approximately 8 per cent of the trees in the grove had been killed by Clitocybe rot. During one year preceding this date six trees were killed by mushroom root rot.

In August 1955 the trees most recently killed by Clitocybe rot were removed and their roots carefully excavated. In at least one case, some old oak roots and an old oak stump were found within a few feet of a dead lychee (Fig. 3). The oak roots and stump were also dead but were thoroughly infected with Clitocybe mycelium. This finding tends to support the belief of previous investigators of this problem who believed that oak roots, persisting in the soil of newly cleared land, were responsible for initiating the disease in the new plantings.

The role of many species of oaks as carriers of Clitocybe rot is a very interesting one.

Fig. 3. The stump of a lychee tree killed by Clitocybe rot is directly in front of the worker. On the left are the stump and roots of an oak which was cut down when the grove land was prepared for planting. The oak, uncovered in digging out the lychee tree, is permeated by mycelium of Clitocybe. It may have been the source of infection of the lychee.

Oaks can live for years although infected by mushroom root rot. Over a period of many years our oak land has become thoroughly infested with this fungus. When land containing oak trees or oak scrub is cleared for a new planting, many oak roots usually remain in the ground. These roots gradually die of starvation, but, at the same time, if a small Clitocybe infestation is present, it invades the entire remaining root system. When new trees, such as lychee or peach, are placed in such soil, it is easy to see why the infection may soon pass on to them.

When a susceptible tree is infected by this fungus the entire crown and adjacent roots are usually invaded. In removing the stump *and roots* of lychees killed by Clitocybe rot on Merritt Island, the fungus was found to have girdled the crown completely in every case, and to have moved out on all the branch roots for a distance of 3½ to 7 feet. Since each tree is at least 20 feet from its nearest neighbor there was no appreciable overlapping of root areas of adjoining trees. The problem might have been more serious if the roots of infected lychees had come in contact with the roots of healthy trees in the grove.

Control of Clitocybe Rot

It follows from what has been said above that the most favorable site for a new lychee planting, from the point of view of avoidance of Clitocybe root rot, is an area which has been free of oaks and other woody plants for many years. A location of this kind is a field which has been under cultivation to non-susceptible crops over a long period. There are also some areas of Florida such as the Dade County region where Clitocybe rot has not been seen on any plants, apparently because of the distinctive soil conditions which prevail there.

Most new lychee groves, however, will be planted on soil from which oaks of some description must be removed. Obviously the most thorough job possible should be done in ridding such land of all oak stumps and roots. The longer the delay between clearing of the land and planting to lychees, the less the likelihood of infection by root rot. Consequently, if the grower can plant other crops for a few years, this too will reduce the chance of infestation but it should be noted that Clitocybe will remain alive on large roots for 10 years and more.

Once the grove is planted, if infected trees appear they should be removed quickly and the surrounding soil should be carefully excavated to remove any lychee or oak roots which still persist in the soil.

Mere mechanical removal of roots may not be sufficient to prevent infection of replant trees. In the Merritt Island grove previously mentioned, an experiment has been set up involving the fumigation of soil of tree spaces from which dead trees have been removed. Four treatments are being tried on areas 16 feet in diameter, and untreated spaces are being left as checks. These treatments include the injection of carbon disulfide and "D-D" mixture and drenches of formaldehyde and "Vapam". This experiment was begun in October 1955 and results may not be available for a number of years. However, anyone who may want to try these treatments on an experimental basis may obtain details from the author.

Conclusion

Clitocybe root rot can be a serious problem in some plantings of lychees, but experience with other crops and with lychees themselves indicates that proper practices can reduce the hazard of initiating the disease. If Clitocybe is already present, its effect can be minimized by prompt removal of the affected trees and any diseased roots in the ground near the tree. Fumigation of infested soil may also help in freeing the grove of this fungus. With correct management there is every reason to believe that the Clitocybe problem need not be a limiting factor in the introduction of new lychee plantings in Florida.

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