

FUNGAL DISEASES ASSOCIATED WITH PECANS IN SOUTH AFRICA

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<https://www.sappa.za.org/crop-protection/>

1. Pecan scab

Symptoms:

Typical symptoms include initial brown to black powdery spots on a pecan nut that expands and merge with other spots to cover bigger areas (Figure 1). As the spots age, the powdery spores of the fungus become airborne, leaving a blackened crust-like appearance on the nut. Damage to the husk surface results in cracking and allow other pathogens, such as pink mould (*Trichothecium roseum*), to invade the nut and cause the natural oils to become rancid. The causative agent of scab (*Cladosporium cladosporioides*) can also cause leaf spots and blackened stems in the surrounding area of the leaves. When individual spots enlarge, they can fuse to form large necrotic lesions on the leaves. However, it has been observed that severe symptoms of scab can be experienced on nuts, without necessarily any visible symptoms on the surrounding leaves.

Plant parts affected:

Nuts, leaves and green stems in the vicinity of the leaves

Causative agent:

Cladosporium cladosporioides

Disease distribution:

Northern and eastern parts of South Africa (mainly Limpopo, Mpumalanga, Kwazulu-Natal and Eastern Cape) (Figure 2)

Comments:

Pecan scab in South Africa is caused by *Cladosporium cladosporioides*, unlike in the USA where *Venturia effusa* (previously known as *Fusicladium effusum* and changed to *V. effusa* in 2016) is the causative agent. During scab, the outer layer of the shuck is damaged, and expansion of the nut, especially during the early stages of development, is of concern. However, when scab is experienced later in the season, after nut filling, damage to the nut is not regarded as crucial.

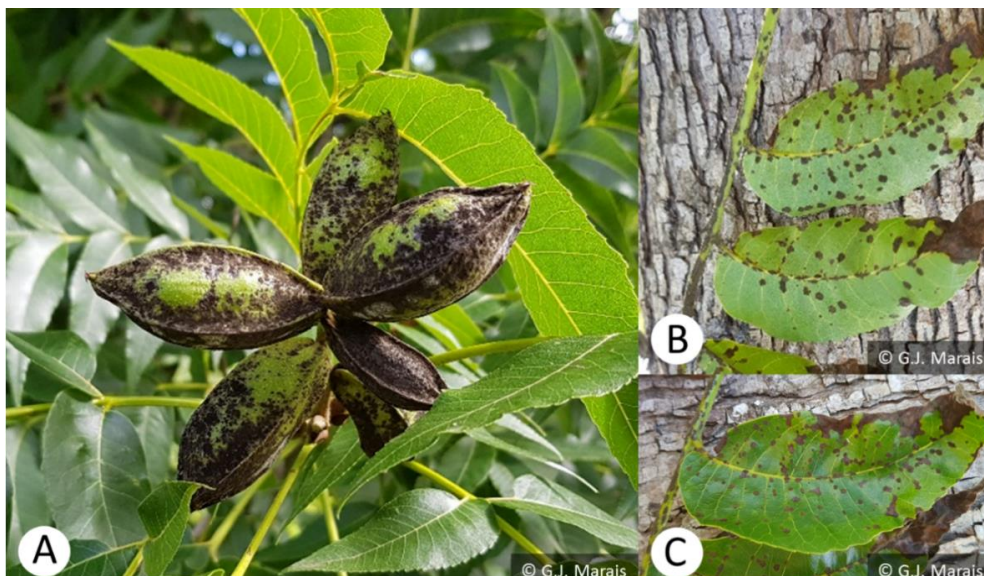


Figure 1: A) Typical scab symptoms, caused by *C. cladosporioides*, on a pecan nut. B) Leaf spots (scab) on the stem and bottom side of a pecan leaf. C) Leaf spots (scab) on the stem and upper side of a pecan leaf.

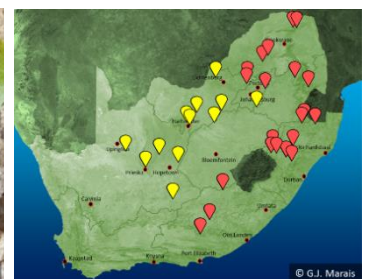


Figure 2: Distribution map of *Cladosporium cladosporioides* in pecan orchards (yellow and red pins), but scab on nuts and leaves are only found in the eastern parts of South Africa (red pins).

2. Die-back

Symptoms:

It is known that pecan trees undergo natural die-back when plants are under stress due to environmental conditions such as drought, flooding, nutrient deficiencies, and extreme temperature fluctuations (Figure 3). In such cases, die-back is observed as an overall die-back over the whole canopy of the tree. When dead branches are cut, no discolouration of the heartwood or sapwood is observed. However, in some cases physical damage is experienced, such as hail, pruning, insect invasion, or strong winds. This can lead to fungal infection by the Botryosphaeriaceae, although these fungi do not necessarily need a physical wound to cause infection. When branches are cut, off-centred brown discolouration of the heartwood and sapwood can be observed, which indicates fungal infection, and not necessarily natural die-back due to environmental stresses.

Plant parts affected:

Mainly twigs, branches and stems

Causative agents:

Neofusicoccum parvum, *Dothiorella* sp. and *Lasiodiplodia* sp. *Alternaria alternata* has also been isolated from die-back lesions, but this could be due that this fungus being an endophyte in most living plant material.

Disease distribution:

All pecan production areas in South Africa (Figure 4)

Comments:

Current recommendations to the producer is to remove die-back branches on a regular basis. When cut open, brown discoloured wood should be cut back until no discolouration is visible. Infected branches should be removed from the orchard to prevent inoculum build-up and re-infection of healthy tissue. Stink bugs have previously been found to carry *N. parvum*, but is likely just by accident, and not necessarily a symbiotic relationship between the fungus and insect.

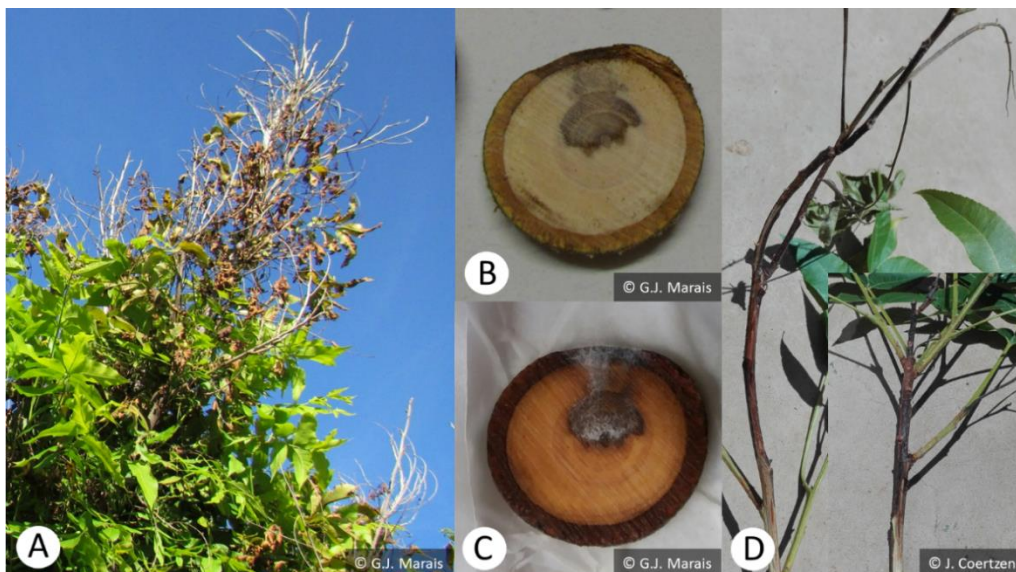


Figure 3: A) Die-back of pecan. B) Off-centred brown discolouration of the heart- and sapwood due to infection by *Neofusicoccum parvum*. C) Fungal growth from the brown lesion after incubation. D) Die-back of a one-year-old test pecan tree after inoculation with *N. parvum*.



Figure 4: Distribution map of *Neofusicoccum parvum* die-back in pecan orchards (purple pins).

3. Black blotch

Symptoms:

Nuts becoming black discoloured, where the whole nut is becoming totally black within less than two weeks (Figure 5). Brown discolouration of leaves normally develop between veins, resulting in square necrotic lesions. Although the progression of the black discolouration of the nuts are rapid, leave necrosis is mostly limited to small parts of a leaflet. However, due to the fact that this fungus (*Neofusicoccum parvum*) is also causing die-back, clusters of leaves and nuts can become necrotic due to lack of water and nutrient supply. In such cases, the typical symptoms of black blotch on the nuts and leaves are not visible. It is only when the reason for the die-back of the branch is found, that a connection can be made to *N. parvum*.

Plant parts affected:

Nuts and leaves

Causative agent:

Neofusicoccum parvum

Disease distribution:

All production areas of pecans in South Africa (Figure 6)

Comments:

Neofusicoccum parvum has been isolated from healthy pecan material as well, which is an indication that this fungus is an endophyte of pecans. The fungus, therefore, can be latent in the plant tissue, until the plant becomes stressed, after which disease development can occur. It has previously been isolated from stink bugs in the Hartswater area, and therefore, visiting insects, especially those that can cause damage to the nuts, should be kept in mind as likely vectors of the fungus. However, no scientific evidence to prove this currently exists.



Figure 5: A) Black blotch in pecan nuts in the field. B) Black blotch on detached nuts, artificially inoculated under laboratory conditions. C) Rectangular leaf necrosis on artificially inoculated plants in the greenhouse. D) Sporulation of *Neofusicoccum parvum* on pecan wood.

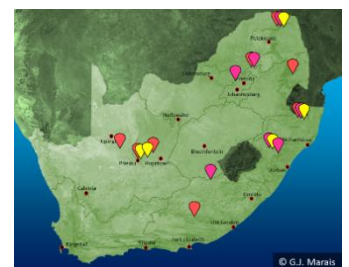


Figure 6: Distribution map of *Neofusicoccum parvum* leaf blotch (red pins), black blotch on nuts (pink pins) and healthy plant material (yellow pins).

4. Alternaria black spot

Symptoms:

Sunken black lesions develop on nuts (Figure 7). The symptoms are very similar to anthracnose on pecans that is caused by the fungus, *Glomerella cingulata*, in the USA. In South Africa, *Alternaria* black spot is caused by *Alternaria alternata*, which is also capable of causing leaf spot. It is visible as a brown circular necrosis that can either appear as a small spot when an infection is just initiated, or becoming larger. The lesion normally affects the fleshy parts of the leaf, but is not limited between the veins. Sometimes, lesions start on the edge of the leaflets from where it spread and can affect a substantial part of the leaflet. This fungus has also been isolated from pecan trees showing die-back, but could be a secondary pathogen.

Plant parts affected:

Nuts and leaves

Causative agent:

Alternaria alternata

Disease distribution:

All pecan production areas in South Africa (Figure 8)

Comments:

Alternaria alternata is constantly isolated from diseased, as well as apparently healthy, plant parts of pecans. This fungus is known to occur as an endophyte in plants without causing any disease symptoms, but when plants seem to experience stress due to external factors, the fungus can become aggressive and cause disease. *Alternaria alternata* was found in all the pecan growing areas in South Africa, and in most pecan samples analysed over the last couple of years, indicating that this fungus is omnipresent and likely already present when young pecan trees are planted in the field from nurseries. To eliminate this fungus from plant material is practically not possible, but making sure that the plant is well looked after in terms of nutrition, enough water, and good practices could keep the fungus at bay.

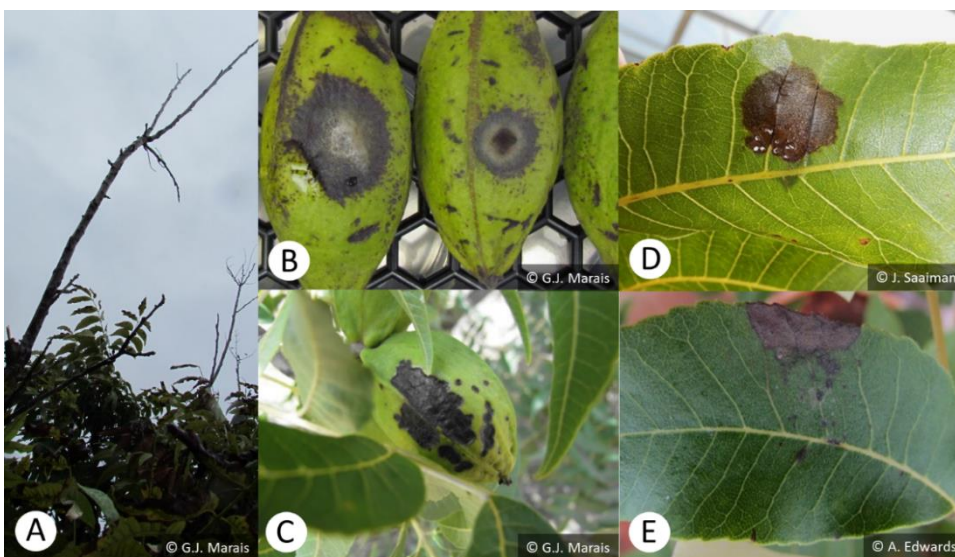


Figure 7: A) Die-back with a combination of *Alternaria alternata* and *Neofusicoccum parvum* infestation. B) Artificial inoculation with *A. alternata* on detached pecan nuts. C) *Alternaria* black spot on a pecan nut in the field. D) *Alternaria* black spot (circular lesion) on a pecan leaflet. E) *Alternaria* black spot on the edge of a pecan leaflet.



Figure 8: Distribution map of *Alternaria alternata* (red and yellow pins), the red pins indicate where *Alternaria* black spot was found and the yellow pins indicate where apparently healthy plant material was collected that contained *A. alternata*.

5. Necrotic lesions around beetle galleries

Symptoms:

Necrotic lesions develop around the galleries of the polyphagous shot hole borer, *Euwallacea fornicatus* (Figure 9). The beetle carries fungal spores with it, and when galleries are made, these fungi grow into the sapwood to absorb nutrients and produce fruiting structures in the galleries that serve as food for the insect larvae and adult insects. Other fungi also invade these lesions that are not necessarily carried by the beetle, but originate from contamination in the surrounding area, or by fungi endophytic to pecans. The infection of the fungi can potentially spread further into the healthy wood, leading to substantial damage and even death of branches or the tree as a whole.

Plant parts affected:

Stems and branches

Causative agent:

Fusarium euwallaceae, *Graphium* sp., *Acremonium* sp., Coelomycetous fungi, other *Fusarium* spp.

Disease distribution:

Jan Kempdorp (Northern Cape) and Nelspruit/Mbombela (Mpumalanga) (Figure 10)

Comments:

Low levels of insect infestation and their fungi seems not to adversely affect the pecan tree. Adult beetles that invade a tree seem to bore the holes only up to a point and do not reproduce in pecans. The reason for this is yet to be determined. Therefore, physical damage by the beetle is limited, but the infestation of the fungi they carry with them, could have a more severe and damaging effect on the pecan tree. The more beetle holes are made, the more points of fungal inoculation exist, and could impact on the ability of the tree to survive an attack from the beetles and fungi.

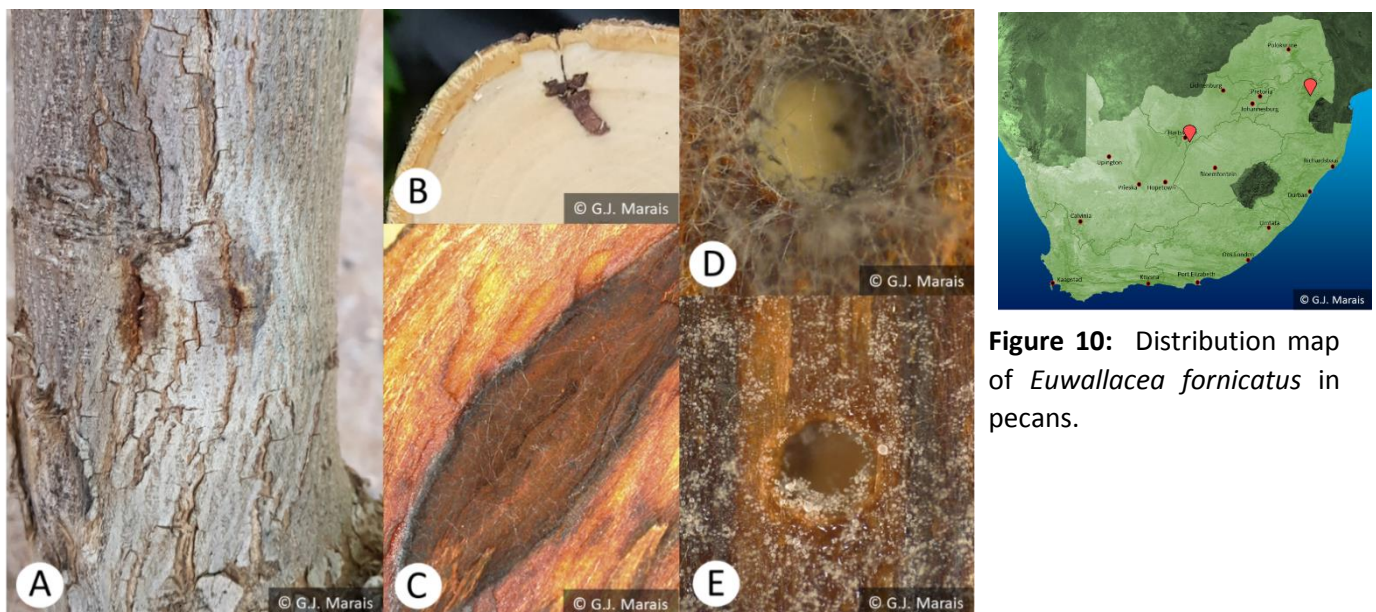


Figure 10: Distribution map of *Euwallacea fornicatus* in pecans.

Figure 9: A) Typical wet spots around the galleries of *Euwallacea fornicatus* due to leakage of wood sap. B) Insect gallery with dark discolouration of the sapwood due to fungal infection. C) Dark discolouration due to fungal infestation around the gallery opening of *Euwallacea fornicatus*. D) *Graphium* sp. fruiting structures visible inside the gallery. E) *Fusarium euwallaceae* colonising the gallery and surrounding darkened wood tissue of a pecan.

6. Overall decline

Symptoms:

Pecan trees, mostly six years and older, show under-developed leaves, which is initially very subtle, but is visible when comparing neighbouring trees (Figure 11). Overall decline affects trees sporadically in an orchard. The next growing season, the leaves are even less developed and a clear difference can be observed between the affected tree and the other trees in the vicinity. Normally after 3 years from the first observation, the tree dies. When the lower stem, normally below the graft is cut, brown lesions are visible, indicating fungal infestation. The root system is also heavily infested with microbial organisms such as fungi, bacteria, nematodes and insects

Plant parts affected:

The whole tree, including leaves, branches, stems and roots

Causative agent:

A combination of fungi, bacteria, and insects.

Disease distribution:

All pecan production areas in South Africa

Comments:

Producers try to combat the overall decline of trees by increasing nutrients and using fungicides. Another method used is to prune the canopy. In some cases, producers experience an overall improvement of the tree. However, this is only temporary and when the canopy grow again in size, overall decline symptoms are back. Overall decline is experienced due to a dysfunctional root system, as well as damage and blockage of the xylem and phloem in the lower stem, especially below the graft lesion. These damages are permanent, and recovery of the tree is basically not possible. It is recommended that when trees are showing signs of overall decline, that removal of the tree should be considered. It could take another 2 to 3 years before such a tree will die, and then additional years have been lost where a producer could rather have planted a new tree in the first year. This will save the producer approximately 2 years to get to full production again.

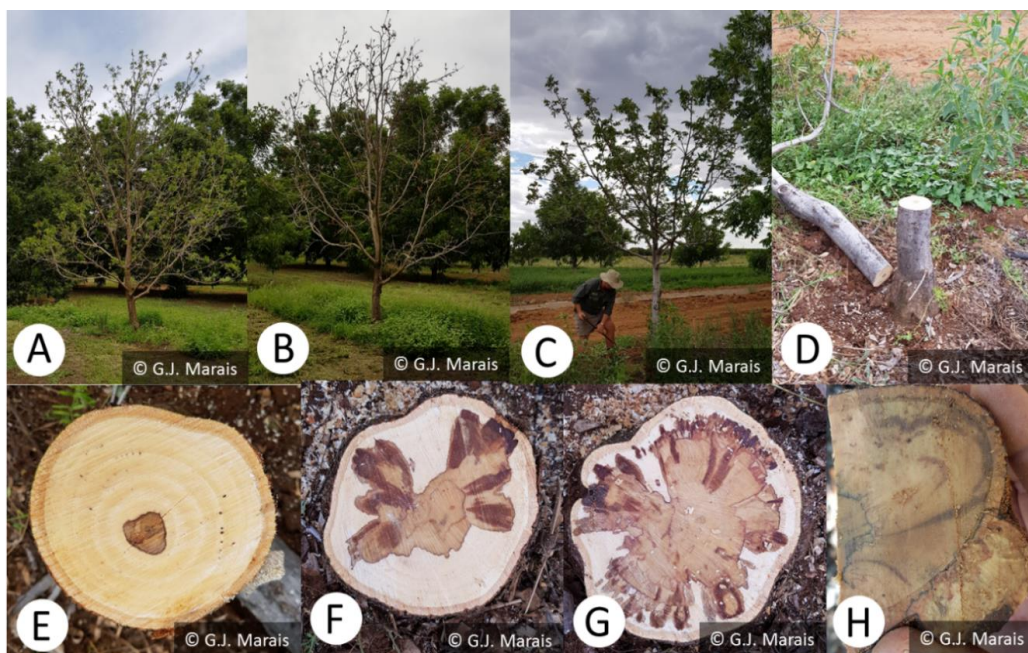


Figure 11: A) Pecan tree showing overall decline in the first year. B) Pecan tree showing overall decline in the second year. C) Six-year old tree showing overall decline compared to the neighbouring tree with the same age. D) and E) The six-year old tree cut off above the grafting lesion. F) Six-year old tree cut off just below the grafting lesion. G) Six-year old tree cut off just above soil level. H) Roots of the six-year old tree showing lesions.

7. White and brown rot

Symptoms:

Symptoms could be quite diverse. White and brown rotting fungi normally consist of those that produce macro-fruiting structures such as mushrooms, toadstools, bracket fungi, and puff balls. These fungi can either grow saprophytically on dead organic material, or can cause the rotting of living plant material by either colouring the wood brownish or whitish. Those fungi that break down lignin, leave the cellulose behind that give the plant material a whitish colour. On the other hand, those fungi that degrade cellulose, colour the wood brownish because of the lignin that is still intact. Nevertheless, in both cases the wood becomes light weighted and can cause death of the tree. In many cases, these fungi cause overall decline when infection is experienced in the lower part of the tree, normally below the grafting lesion.

Plant parts affected:

Lower stems and roots

Causative agent:

Basidiomycetous fungi such as mushrooms, toadstools, bracket fungi, and puff balls. Identification of these fungi are still ongoing in the UFS/SAPPA project, but preliminary results indicate fungi such as *Ganoderma* and *Coprinellus*.

Disease distribution:

It is expected to be in all the production areas of South Africa, but has specifically been observed in the Hopetown and Prieska areas in the Northern Cape, Louis Trichardt in Limpopo, and Muden in Kwazulu-Natal.

Comments:

White and brown rot is very frequently associated with overall decline. Therefore, what is relevant to overall decline, is also relevant to white and brown rot. Many basidiomycetous fungi are secondary invaders and degrade dead or dying plant material. One should, therefore, be aware that the presence of these fungi could be an indication of other underlying problems in the tree.

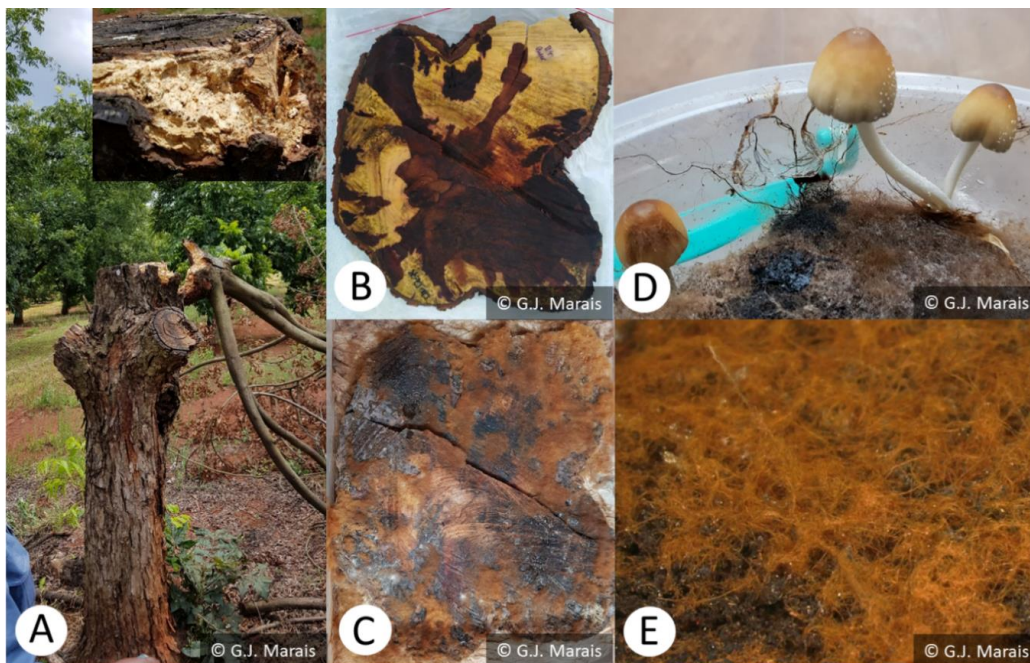


Figure 12: A) Pecan tree with a graft branch broken off due to white rot. B) Pecan stem disk of a tree showing overall decline with brown discolouration. C) Emergence of a brown rotting fungus from the disk. D) Fruiting structures of *Coprinellus micaceus* emerging from the brown growth. E) Hyphal growth of *C. micaceus*.

Notes from the author

This booklet was compiled based on information gathered from an ongoing project between SAPPA and the University of the Free State. Therefore, the data shared here is part of a number of post-graduate studies, in many cases these studies have not yet been concluded. As these studies progress, data will be updated in future reports and publications. This booklet is, therefore, seen as a first version, and would be expanded as new findings and data become available in future.

The author wish to thank the students and technical people involved in the SAPP/UF/ project for their commitment and efforts to generate valuable data for the industry. A humble thanks and appreciation to SAPP and producers to make this work possible and that the Pecan Health Research Group at UF, can be part of such a project.

Although more than a hundred fungal species have thus far been associated with pecans in South Africa, only a few have been recognised to be of importance to affect the health of pecans. The information given here are based on this initial data. However, it is likely that other fungi could also play a role in causing disease, but has not yet been fully investigated how they affect the health of pecans. This will form part of ongoing research and feedback from the industry in an attempt to understand the unique health problems pecans are facing at the southern tip of Africa.

