Plant Pathogenic risks of pecans in South Africa

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Since the commencement of the project between SAPPA and the University of the Free State at the beginning of 2017, a total of 4 honours and 2 MSc studies have been concluded. In addition, 4 MSc and 2 PhD studies are still ongoing, covering some of the more important plant pathogenic risks identified by the industry. Although a number of projects are currently undertaken under the umbrella of the Pecan Health Research Group at the UFS, some have progressed as such to report here. In addition, some developments during the past year are also discussed.

An example is the use of the word: "anthracnose". Until recently, it was used to describe the sunken black lesions on pecan nuts in South Africa that were caused by the fungus, *Alternaria alternata*. However, similar symptoms are caused by the fungus, *Glomerella cingulata*, which is described for many years to cause anthracnose on pecans in the USA. The latter fungus is also implicated on a wide variety of crops globally to cause anthracnose, and therefore the word "anthracnose" has been cornered by plant pathologists and agriculture to describe plant diseases caused by fungi of *Glomerella*, or its asexual stage, *Colletotrichum.* Collections of black sunken lesions on pecan nuts over the last three years in all production areas in South Africa, has not delivered any evidence of the presence of *Glomerella*. However, *Alternaria alternata* is constantly isolated from these lesions, indicating that anthracnose in pecans is the incorrect term to describe the disease in South Africa. It is, therefore, rather more correct to refer to Alternaria Black Spot on nuts, or Alternaria Leaf Spot on leaves. As both fungi produce a sunken black lesion on nuts, or black spots on leaves, the only visible difference is that on the lesions of anthracnose, tiny orange spore masses are visible with a magnifying glass, which is absent in the case of Alternaria Black Spot.

The collection of plant material that show typical symptoms of scab over the last three seasons has resulted in the isolation of 107 fungal cultures of *Cladosporium* from all the production areas of South Africa. This was part of the MSc study of Nicola Theron, who specifically focussed on the distribution and identification of *Cladosporium* species associated with pecan scab in South Africa. Although the focus was on collecting fungi associated with scab (mainly from Scheerpoort, Limpopo, Mpumalanga, KZN and Eastern Cape), air samples were also taken from areas where scab is known to be absent (Northern Cape, Northwest, and Free State). Genetic sequencing of the cultures indicated that a wide variety of fungal species, belonging to the *Cladosporium cladosporioides* species complex, were found. These include five known species and seven unknown species that will be described as new. None of the fungal species were found to be *Venturia effusa*, which is the causative agent of pecan scab in the USA, and confirm that scab in South Africa is unrelated to scab in the USA. What is concerning is the wide base of genetic diversity among the members of *Cladosporium* associated with scab in South Africa (12 species). This indicates that *Cladosporium* had the opportunity to diversify widely on pecans as a host in South Africa, which could lead to further genetic diversification and ultimately resistance to currently used fungicides.

Previous studies in the Hartswater and Prieska areas indicated that *Neofusicoccum parvum* can cause black blotch on nuts. The focus of the MSc study of Jolene Coertzen in the current project indicated that this fungus is widely distributed in pecans, including the eastern parts of South Africa. It was also found that *N. parvum* can cause die-back and was the most prominent fungus of the Botryosphaeriaceae associated with pecans. These types of fungi include some of the more important plant pathogens associated with food crops, natural vegetation, and trees worldwide. In addition, it was shown that other members of the Botryosphaeriaceae were also associated with pecans, including species of the genera, *Dothiorella*, *Lasiodiplodia* and *Botryosphaeria*. Due to the fact that the initial focus of the MSc project was to investigate the pathogenicity of *N. parvum*, and that the other *Botryosphaeriaceae* fungi were only discovered during the concluding phase of the project, the role of these fungi in pecans is yet to be determined.

One of the more important diseases that is observed over the last two years is overall decline. It is not clear whether producers are just more aware of the disease, or whether there is an increase in incidents. Typical symptoms are mostly observed in pecan trees older than six years that show undersized leaves, which is initially very subtle. However, by comparing to neighbouring trees the difference becomes more evident. 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.

Producers attempt to combat the overall decline of trees by applying additional nutrients and fungicides, or pruning the canopy. Sometimes a general improvement of the tree is experienced. However, this is only temporary and when the canopy regrow in size, overall decline symptoms tend to be back. The typical symptoms are 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 is killed, and valuable time is lost where a healthy tree could have been planted earlier.

What became evident over the last year is that trees with overall decline symptoms have different species of microbial infestations that are related to the discolouration of the sap- and heartwood. This is an indication that the initial problem with the tree is most likely not due to the attack by pathogens, but rather an underlying weakness of the root system that allow the gradual infestation of opportunistic fungi into the roots and up into the lower stem. This ultimately influences the flow of water and nutrients to the upper parts of the tree, resulting in overall decline. The exact cause of this disease is not yet understood, but a number of projects have been initiated to study certain aspects of this, including identifying microorganisms in the rhizosphere of pecans showing overall decline.

Coprinellus micaceus is a mushroom that is widely found in vegetation in South Africa. It is known to be a saprophytic fungus that grow on dead plant material. However, over the last two seasons this fungus was regularly isolated from the lower stems of overall decline trees. Previously, this fungus has been associated with

sudden death in citrus trees in Australia in 1945, mostly on trees between 7 to 15 years of age. Pathogenicity tests at that stage indicated that this fungus is a weak pathogen, but the regular isolation from brown discoloured stems from pecan trees in South Africa is of concern. The role of this fungus in overall decline of pecans still needs to be determined.

Over the last production period, a number of cases, where *Ganoderma* species were associated with overall decline, were reported. These fungi are known to cause fungus rot and affect the roots and lower stems of many deciduous trees and some conifers. There are mainly two important species that have been preliminarily identified on pecans in South Africa. These include members of the *Ganoderma lucidum* species complex (causing varnished fungus rot) and *Ganoderma applanatum* (causing unvarnished fungus rot). They attack the lower heartwood, and at advanced stages damage the structural integrity of the tree, often resulting in wind-throw. Trees affected by these fungi may show signs of yellowing, wilting, or undersized leaves and dead branches. Tree vigour may be affected as decay of the sapwood advances. The first visible sign of infection is often the formation of conks of fungal tissue, representing their fruiting bodies on the lower stems and exposed root areas. The upper surface of varnished fungus rot is typically red-brown with a white edge, shiny, and with a lacquered appearance. Conks of the unvarnished fungus rot are brown with a white edge weathering to grey. Both have a white, porous texture on the underside. By the time the conks are noticed, irreversible damage to the trees has already taken place. According to literature, the rate of decay can lead to death within 3 to 5 years from the time of infection, and appears to be determined by tree vigour, which is often influenced by environmental stresses. Currently, there is no solution to the control of these fungi, except to remove young fruiting bodies as they emerge. When these structures mature, millions of spores are produced in the form of a dust cloud that is airborne and can infect other trees. Therefore, it is recommended to consider removing heavily infested trees to prevent further spread in an orchard.

A booklet, discussing the more important fungal pathogens of pecans in South Africa, has been handed to delegates at the Annual General Meeting of SAPPA on 15 and 16 November 2019 in Modimolle. This provides information on the symptoms, disease distribution, the causative agents, as well as additional comments on the various diseases thus far identified in South Africa. The information has been gathered from the ongoing project between SAPPA and the UFS, and the booklet is foreseen to be expanded in future as new data is collected. A modified A4 version of the booklet with most of the information is available on the SAPPA website.