Basal rot makes onion farmers cry

Nature often brings pests or diseases with which farmers have to deal. Such is also the case of onion producers of the Koue Bokkeveld near Ceres, who have to cope with *Fusarium* basal rot (FBR).

SINCE THE 1980s the Koue Bokkeveld has developed into South Africa's main onion producing region, delivering around 160 000 tonnes per year. It is the only area in the country where the typical brown onion is grown, and the only to export significant volumes to countries in Africa and the European Union.

Produce from the Koue Bokkeveld is favoured for their high quality, long shelf life, attractive skin and fair price. Onions from the region also need only a short curing period after being harvest.

In the 1990s, however, a proverbial snake raised its head in this onion-producing paradise: *Fusarium* basal rot (FBR) – a disease that causes serious economic losses in most of the more than 170 onion producing countries.

By 2012, up to 25% of all onions produced in the Koue Bokkeveld were being rejected because of some type of rot. FRB in particular was steadily eating away at producers' profit.

When Stellenbosch University PhD student Michael Southwood, through a KORKOM-funded study, investigated healthy bulbs from 10 farms stored for three months, he found that FBR caused 30% of all onions to be rejected during the 2013 season, and 18% in the 2014 season.

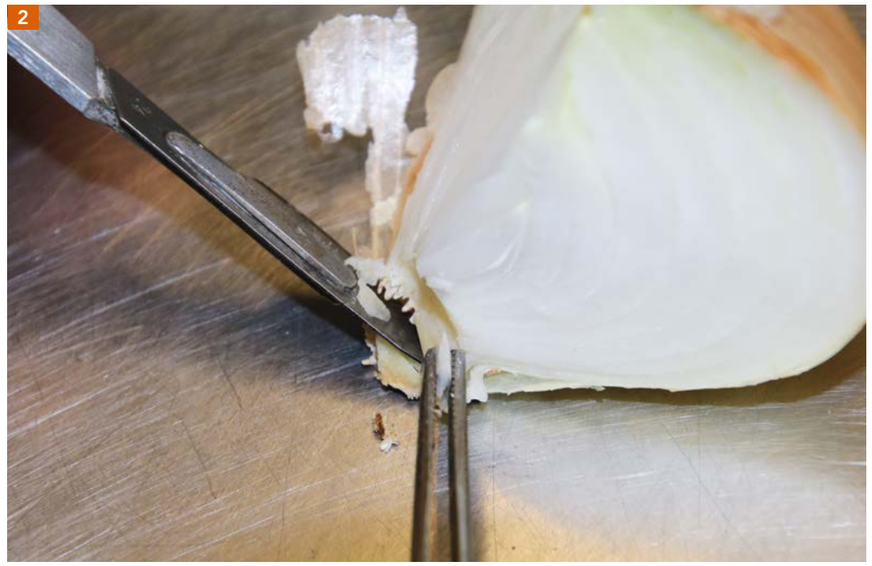
Producers have tried their best to manage the disease. In heavily infested fields, good irrigation and fertilisation practices are helpful, however, in the presence of environmental conditions that favour the development of FBR, severe losses still occur. Crop rotation is also not effective in highly infested fields, because the pathogen can survive for up to a decade in soil in the absence of host plants.

No known FBR-resistant options are available for the intermediate-day onion cultivars commonly farmed within the Koue Bokkeveld. Fungicides are also not the ideal solution, as most fungicides are not systemic and can therefore not be translocated to roots when applied to the foliage. Furthermore, application of fungicides to soil is generally also ineffective, unless it can be taken up systemically by the plant, which is not a characteristic of most fungicides.

1 Prof. Adele McLeod, project leader.
2 Removing the basal plate of a brown onion.
3 Symptoms of basal rot in a young red onion.

In search of alternatives

Prof. Adéle McLeod, of the Department of Plant Pathology at Stellenbosch University, decided to tackle the FBR problem. Having received funding from the PHI Programme and the onion industry, she tasked Masters student Hanli Kellerman to establish whether phosphonates can be used to fight FBR.



Adéle is an expert on fungus-like micro-organisms and soil-borne pathogens. She has been investigating the use of phosphonates to combat, among others, replant disease, or sick soil disease, in apples and avocados.

"Phosphonate is quite a wide term that generally includes the salts and esters of phosphonic acid (H_3PO_3)," Adéle explains. "Phosphites are highly mobile and are translocated upward and downward in plants, which allows for various application methods including foliar applications and soil drenches."

Phosphonates have been used over the years to manage many Phytophthora, and less frequently *Fusarium* diseases in food crops. Potassium phosphonate, ammonium phosphonate and fosetyl-Al (alkyl phosphonate) are among the registered phosphonate products often used to manage root rot.

WHAT IS *FUSARIUM* BASAL ROT (FBR)?

FBR is caused by a persistent soil-borne pathogen called *Fusarium* oxypsorum f.sp. *cepae* (Focep) that infects leek and onion seedlings and mature bulbs. Its spores survive in the soil for years, long after all host plants have been removed, due to its so-called saprophytic ability and ability to produce hardy spores that allows the pathogen to live off dead or decomposed matter.

Bulbs are infected while still growing in the field but symptoms are barely noticeable. Wilting, curving and yellowing of leaves, or tissue damage at the bottom of the bulb itself, is only visible to under highly conducive environmental conditions and in fields containing a lot of the pathogen in the soil.

The disease becomes obvious during storage, in symptoms such as dry rot in an onion's basal plate, and white to pink mycelial growth that further develops into a soft rot.

PROJECT TITLE
The potential of phosphonates for managing *Fusarium* basal rot of onion, and their translocation and persistence in onions

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DURATION
Two years and two months

PHI PROGRAMME & INDUSTRY CONTRIBUTIONS
R312 051 & R162 051

LEAD INSTITUTION
Stellenbosch University (Department Plant Pathology)

BENEFICIARY
The onion industry

FOCUS AREA
Post-harvest insect control, including phytosanitary compliance, and post-harvest physiology

HUMAN CAPITAL DEVELOPMENT
One MSc student and one BSc student

PUBLICATIONS
Two

PRESENTATIONS
Five

1 Onion producers have been plagued by *Fusarium* basal rot, causing rejections up to 30% and resulting in great profit losses.
2 Onion seedlings can be infected with Focep in the nursery.
3 *Fusarium* basal rot on onion (*Fusarium oxysporum* f.sp. *cepae*).*
4 A micrograph of asexual spores of conidia causing FBR in garden onions. (Courtesy of Bruce Watt, University of Maine, Bugwood.org)
5 Onion plants showing leaf symptoms of *Fusarium* wilt in the field.*
6 Onion plants showing *Fusarium* infected basal plates.*
* (Courtesy Howard F. Schwartz, Colorado State University, Bugwood.org)

Importantly, the US Food and Drug Administration (FDA) classifies phosphonates as a GRAS, or generally regarded as safe, product.

This project took the research team into unchartered territory. Only a few studies have been conducted on the use of phosphonates on onions or leeks, but none have yet specifically investigated its value to suppress FBR.

Adéle's interest in giving it a shot was triggered by a handful of onion farms in the Koue Bokkeveld who were using foliar sprays containing ammonium phosphonate to control downy mildew.

"We heard that these farms had exceptionally high post-harvest quality," she says. "Whether it was in fact ammonium phosphonate that contributed towards improved post-harvest quality had not been quantified and determined experimentally on these farms, but warranted further investigation."

The researchers set themselves the following objectives:

- Optimise and develop a method to quantify the development of symptoms caused by *Fusarium oxysporum* f.sp. *cepae* (Focep) in artificially inoculated onion basal plates in onion seedlings and mature bulbs;
- Determine *in vitro* whether Focep is sensitive to the use of phosphite, as influenced by phosphate;
- Develop an analytical method to quantify phosphite from onion basal plates and roots;
- Determine whether timing and different dosages and application methods play a role in suppressing FBR with ammonium phoshonate; and
- Determine the effect of ammonium phosphonates on mycorrhizal colonisation.

DAY AND NIGHT HOURS

Bulb onions are highly influenced by the length of days and nights. Different types of onions have different light (and dark) requirements.

Regardless of when an onion is planted, the amount of dark and light that a bulbing onion is exposed to strongly influences when and if they will bulb, flower and set seed.

The varieties of onions that require a shorter period (11 to 13 hours) of daylight to bulb are termed "short day" onions. Those that require the longest period of daylight (14 hours per day or more) to form bulbs are known as "long day" onions. Those with intermediate requirements (from 13 to 14 hours of light per day to bulb) are called, logically, "intermediate" onions.

Because location (latitude, or distance north or south of the equator) determines day length, some varieties of onions are not as suited for some locations.

Results and implications

The study standardised various testing methods for South African conditions and onion cultivars.

- DNA extraction and Focep specific quantitative PCR (qPCR) methods from plant tissue and soil were developed using standardised techniques.
- A sensitive, rapid and specific liquid chromatographic-tandem mass spectrometric (LC-MS/MS) method for quantification of phosphite in onion basal plates and roots.
- A phosphonate agar assay was amended to evaluate *in vitro* the sensitivity of Focep isolates to phosphonates. It showed that Focep is not sensitive to phosphite based on radial growth.
- The cytotoxicity assay was optimised to test the sensitivity of Focep to phosphonates, using a liquid medium. The assay can also be used to measure whether the addition of phosphite inhibits spore germination.

"qPCR quantification of Focep in soil can be valuable for not only selecting fields for trial sites and optimising trial design layout, but also for growers in making management decisions," says Adéle. "From nursery and glasshouse trails we learnt that phosphonate soil sprays work best to attain high phosphite concentrations of phosphite in onion seedlings."

Field trials conducted in 2015 on whether ammonium phosphonate and mycorrhiza can supress FBR did not yield promising results. "It was probably because phosphonate was applied too early in the season, resulting in too low root and basal plate phosphite concentrations," says Hanli.

Come harvest time in 2017, she will know whether her latest series of field trials have been more successful. "We started spraying phosphonate in the nursery, and continued to do so throughout the season," explains Adéle, while holding thumbs.