VERTICILLIUM WILT

potatoes aartappels SA

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VERTICILLIUM WILT

Verticillium wilt affects potato production in virtually all parts of the world where the crop is grown and is caused by the fungi of the genus *Verticillium.* Worldwide seven different *Verticillium* species have been associated with wilt of potatoes, namely *V. albo-atrum, V. dahliae, V. isaacii, V. nonalfalfae, V. nubilum, V. tricorpus and V. zaregamsianum,* with *V. dahliae* being the most aggressive and more common specie on potato crops. In South Africa only *V. dahliae* was isolated from symptomatic potato plants in a comprehensive survey conducted between 1995 and 2000 in 13 production regions in the country. A recent survey in the Sandveld confirmed that *V. dahliae* was the main specie associated with Verticillium wilt.

Although *Verticillium* commonly causes wilt, conclusive diagnosis requires laboratory techniques of which plating of a thin piece of vascular tissue on culture medium and microscopical examination of the resultant fungal growth, is the simplest. Modern molecular techniques can be employed in addition to the conventional methods.

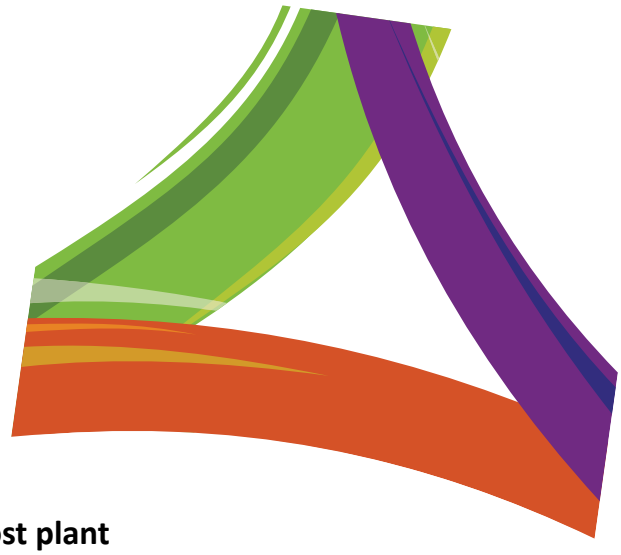
DAMAGE

Verticillium is a pathogen that invades xylem vessels, disrupts water transport inside plants, thereby causing wilt in plants. Yield losses caused by Verticillium wilt vary but can be as high as 50% in susceptible potato cultivars, and less in tolerant ones.

Premature vine death and declining yields are well-known problems in many areas of the world where potatoes have been produced for many years, resulting in it being called the **Early Dying Disease Syndrome**.

The fungi *V. dahliae* and *C. coccodes*, soft rot, the nematode *Pratylenchus penetrans* and nutrient deficiency are associated with the Early Dying Disease Syndrome of potatoes. *V. dahliae* is generally considered the primary pathogen in the disease complex.

THE DISEASE TRIANGLE



Pathogen

- Verticillium wilt in South Africa is caused by *Verticillium dahliae*.
- *Verticillium dahliae* has a host range of over 200 plant species.
- *V. dahliae* forms microsclerotia that survive in soil for many years (over ten years).
- Verticillium wilt is an important component of the Early Dying Disease Syndrome that can occur from the flowering stage.

Host plant

- Cultivars vary from tolerant to susceptible.
- Stress conditions predispose plants to Verticillium wilt.
- Some plants, including weeds, serve as harbouring asymptomatic hosts where the fungus has the ability to survive on the roots of the plant or inside the vascular tissue.

Environment

- Warm temperature (22-27°C) and high soil moisture are conducive to Verticillium wilt.
- The higher the level of soil infestation, the greater the risk of Verticillium wilt.

MANAGE THE RISK OF VERTICILLIUM WILT

	RISK	MANAGEMENT
PLANTING TIME	The crop will mature during hot seasons	- If a field is known to be infested with *Verticillium*, select a planting time to avoid hot, moist conditions during the latter part of the season.
CHOICE OF FIELD	*Verticillium* inoculum in soil and on plant debris	- If possible, avoid planting on fields with a history of Verticillium wilt for a number of years.
CHOICE OF CULTIVAR	Susceptible cultivars	- Where possible, plant cultivars that are known to be tolerant to *Verticillium*. Information on popular local cultivars is, however, not available at this stage.
SEED POTATOES	Uncertified or old seed potatoes	- Plant only good quality, certified seed potatoes. - Poor seed give rise to weak plants predisposed to Verticillium wilt.
CROP MAINTENANCE	Plants are weakened by external stress factors	- Make sure that the fertilizer programme provides well balanced nutrition, particularly during the early stage of the season. - Apply irrigation judiciously to avoid overly wet or dry conditions.
	Impaired root function	- Control nematodes as infection will impair root function, thus nutrient and water uptake and causes weakened plants. - Avoid low lying areas prone to water logging.
	Climate favourable for disease development	- Make sure a good spray programme is followed from early-on to prevent foliar diseases and insect damage to limit stress on plants as much as possible.
POST HARVEST TILLAGE	Survival structures on plant debris and in soil serve as inoculum source	- Control volunteer potatoes and weeds as they will serve as a continuous source of inoculum.

DISEASE DEVELOPMENT

***Verticillium dahliae* is a monocyclic pathogen on potato:**

- The size of the initial inoculation level in soil does not increase during a single season of planting potatoes, unless additional inoculum is carried into the field from an external source.
- Verticillium wilt may not be evident in the first season after introduction of inoculum into a field.
- The level of inoculum increases by repeated planting of host plants, and with that the disease becomes more serious.

In soil, microsclerotia are stimulated by exudates of roots of suitable host plants to germinate. Hyphae penetrate the root tips, colonise the cortex, and progress to the vascular tissue where spores are spread throughout the plant. The xylem vessels become blocked by fungal growth and restrict the uptake of water and nutrients.

Although infection may occur early in the growing season, wilt symptoms often do not develop until the latter part of the season when tuber bulking occurs. Wilting of leaves and stems eventually result in early death of the host plant, resulting in a reduction of yield and tuber size. As the host dies, microsclerotia form within the senescent tissue, which are released into the soil as the plant debris decomposes, increasing the level of inoculum for successive crops.

Verticillium wilt develops when the level of propagules in soil reaches a critical threshold level. Local research indicated that this level can be as low as 0.5 microsclerotia per gram of soil. Repeated planting of susceptible hosts increases the inoculum level and the risk of disease.

Infected plants showing leaf yellowing and wilting do not always show typical vascular discoloration of stems and tubers. All plants showing wilting and leaf discoloration, should therefore the seen as possibly infected with *Verticillium*. Approximately 50% of the tubers of an infected plant, will also be infected by *Verticillium*.

V. dahliae may enter stems growing from infected seed tubers. Tuber-borne inoculum, however, has little effect on Verticillium wilt symptoms or yields under normal circumstances. The significance of infection of seed tubers is that the pathogen is introduced into the soils not previously grown to potato, or where the soil has been fumigated to reduce soil-borne inoculum.

Conditions conducive to disease development

Warm soil temperatures (22–27°C) favour the development Verticillium wilt caused by *V. dahliae*. The disease is usually associated with one or more stress conditions, e.g. under or over fertilisation, insufficient or excessive rainfall and irrigation, high salinity of irrigation water and the presence of other organisms such as nematodes, *Colletotrichum coccodes* and *Pectobacterium* spp.

SURVIVAL IN SOIL

Microsclerotia are multicellular, melanised resting structures which are resistant to unfavourable conditions and fungicides, and are able to survive in the soil for long periods (ten years) in the absence of a susceptible host.

Soil and plant debris. Microsclerotia and hyphae occur mostly in the top 30 cm of a field, but they can occur in deeper soil layers as well. Inoculation densities in soil and disease severity increase as potato and other hosts are planted without proper rotation.

Volunteer potatoes and other host plants maintain and increase the level of microsclerotia in the soil.

Other host plants. Verticillium has a wide range of host plants, of which members of the Solanaceae family such as tomato, peppers and tobacco. Solanaceous weeds include: black night shade, thorn apple, bug weed, wild gooseberry and bitter apple.

Other crops include: sunflower, soybean, peanut, cotton, lucerne, cucurbits such as watermelon, beets and some brassicas (cabbage, cauliflower).

A long list of weed plants has been reported to be hosts of *Verticillium* and includes: khaki weed, nut sedge, wandering jew, pennywort, horseweed, sow thistle, common dandelion, purple top, etc. Also refer to the latest version of **Potato South Africa's Host Plant Table**.

SPREADING OF THE DISEASE

Microsclerotia are the primary source of inoculum in an un-infested field. More than 90 000 microsclerotia can be introduced into soil by a single infected stem. Infested soil on the surface of seed potatoes can also be a primary source of spread. Once established in soil, spreading of the pathogen occurs primarily through soil cultivation and movement of soil through water and wind.

Within the plant. *Verticillium* enters the plant through root tips and grow through the cortex and into the xylem vessels. In the xylem vessels spores and hyphae are transported through transpiration stream and spread to stems and petioles.

Seed potatoes. Infected tubers can spread the disease over long distances to non-infested fields. Not all tubers of infected plants are infected with *Verticillium*

PRINCIPLES OF DISEASE MANAGEMENT

Verticillium wilt develops when the number of propagules in the soil reach a critical threshold level. **The higher the number of microsclerotia in soil, the higher the risk of Verticillium wilt.** Repeated planting of susceptible hosts increases the microsclerotia population and the risk of disease.

Management of Verticillium wilt is based on lowering the level of microsclerotia in soil to levels too low for disease development on susceptible cultivars.

Practices should also aim to prevent introduction of the pathogen to areas where the inoculum level is below the threshold level.

To reach this goal an integrated strategy employing various elements is required.

Verticillium dahliae probably occurs in most soils where potato is grown in South Africa. To ensure sustainable potato production, an integrated approach to reduce the inoculation level include crop rotation, soil fumigation, green manure, soil solarisation and bio-fumigation.

- Avoid **fields with a history of Verticillium wilt**. Crop rotation for at least 3-4 years with grasses or grain crops may reduce the prevalence of the disease in the soil. It is important to control volunteer potatoes.

- Potential **crops suitable for rotation** include: barley, bluegrass, carrot, maize, wheat and grain sorghum.

- Planting of **tolerant cultivars** is effective in reducing the effect of Verticillium wilt on yield. In greenhouse trials of ARC-Roodeplaat over three years (2003–2005), Mondial, Mnandi and Herta were classified as moderately tolerant, and BP1, Pentland Dell and Up-to-Date as susceptible. The relative tolerance levels of popular cultivars such as Sifra, Valor and Lanorma have not been evaluated. Note that planting of tolerant cultivars does not lead to reduced levels of microsclerotia in soil. Planting of resistant cultivars would be a very effective way of controlling Verticillium wilt. However, resistant cultivars are not currently available, but through plant breeding such cultivars may become available in future.

- Plant **certified seed tubers.** *Verticillium* infected tubers do not show symptoms characteristic of the pathogen. Because seed potatoes are inspected visually for pathogens, no tolerance levels for *Verticillium* are included in the South African Seed Potato Certification Scheme. Seed growers are required to maintain rotation programmes and they rouge fields regularly. Any plant showing wilt symptoms is removed, thereby reducing the risk of spreading *Verticillium* through certified seed potatoes.

- **No fungicide** is currently registered in South Africa for the control of Verticillium wilt.

- The disease can be controlled by a variety of pre-plant soil **fumigation** treatments, such as metham-sodium. However, depending on the inoculum potential of the soil, soil fumigants are not always sufficient to reduce the inoculum density in the soil.

- **Biofumigation**, i.e. the incorporation of residues of brassicaceous crops such as broccoli and caliente mustard. into the soil has provided significant control of Verticillium wilt on various occasions. Brassicas produce glucosinolates which can be converted to chemicals with fumigation properties. Growing bio-fumigation crops is not a silver bullet, but the practice has been shown to contribute to controlling not only *Verticillium* spp, but also *Streptomyces* spp causing common scab, *Spongospora subterannea* causing powdery scab and some nematodes. Knowledge of the disease history of a field

or a farm is important as *Brassica* spp are hosts of *Sclerotinia sclerotiorum*, causing white mould. In such case, it would be wise not to include brassicas as a cover or rotation crop. The biofumigant crop is chopped and incorporated into moist soil, the soil sealed and left for at least two weeks for the fumigants to take effect. Very little research has been done on the use of brassica crops for the management of Verticillium, but the first studies indicated that the practice has potential in South Africa.

- **Sanitation** is important for preventing the introduction of the pathogen into wilt-free fields and in reducing losses from wilt in infested fields. Soil infested with *Verticillium* propagules may be introduced to other fields through livestock, implements and vehicles.
- Effective **nematode** control is important. Lesion nematodes cause micro wounds in roots because they continuously enter and exit roots.
- Control of **volunteer potato plants and weeds** prevent an increase of *Verticillium* inoculum level in soil. Many weeds are hosts plants to *Verticillium*, especially solanaceous weed species. Volunteer control is important to limit the increase of inoculum levels of *Verticillium* as well as other soil-borne pathogens such as *Fusarium, Streptomyces, Colletotricum* and nematodes.
- **Reduce causes of plant stress** such as an unbalanced fertilization program, soil-borne and foliar diseases, insect pests and nematodes and therefore susceptibility to Verticillium wilt.
- **Judicious irrigation** management early in the season is recommended, since high soil water content during tuber initiation increases infection, whereas low soil water content after infection aggravates symptom expression.
- A registered **biological product** for the control of Verticillium wilt can be applied according to the manufacturer's recommendations.
- **Soil solarisation** by covering the soil surface with a transparent plastic film has been used to reduce the level of infestation in fields. The success of the practice is determined by soil texture, temperature, soil moisture and the amount of cloud cover and rainfall. Disadvantages include disposing of the plastic polyethylene film in a responsible manner and leaving the field idle for extended periods.

VASCULAR BROWNING CAN BE THE SYMPTOM OF VERTICILLIUM WILT, FUSARIUM WILT OR PHYSIOLOGICAL DISORDERS

Physiological vascular browning is generally associated with a combination of low soil moisture (moisture stress) and sudden foliage die-off as a result of chemicals, frost or mechanical damage. High temperature during foliage die-off normally increases the seriousness of discolouration.

VERTICILLIUM WILT CAN BE CONFUSED WITH OTHER WILT DISEASES

Verticillium wilt can easily be confused with Fusarium wilt caused by *Fusarium oxysporum* and *F. solani*. The first symptoms of Fusarium wilt usually occur in the middle of the growing season when infected plants turn a lighter colour, followed by wilting, yellowing and curling of the lower leaves. Sometimes the growing tips of infected plants show a purple discolouration and aerial tubers can form in the leaf axils. Infected plants eventually die prematurely. In infected plants, both the root cortices and the plant stems may exhibit a corky decay, and when the plant stems are bisected typical browning of the vascular bundles is observed

Fusarium wilt and Verticillium wilt differ from Bacterial wilt in the sense that the wilting caused by Bacterial wilt is more severe and without yellowing of the leaves.

Symtoms of Bacterial wilt

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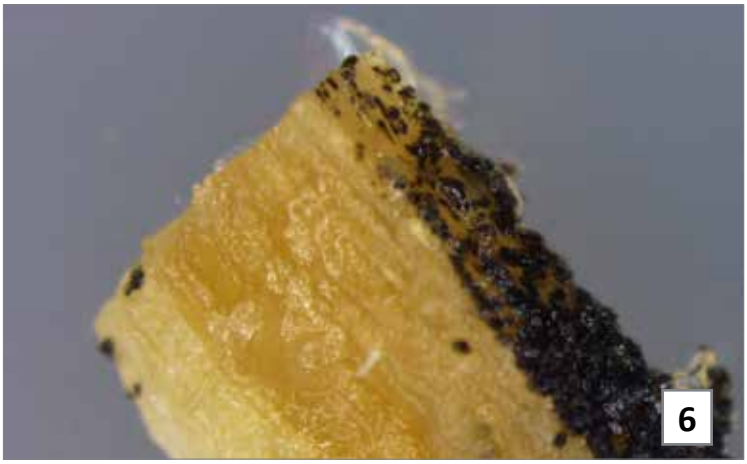
SYMPTOMS OF VERTICILLIUM WILT

The first symptom to appear normally is yellowing on the lower (oldest) leaves of individual or groups of plants scattered amongst healthy looking plants (1&2). Wilting and necrosis then follow and progress upwards from the base of the stem resulting in premature death (3&4). Most of the necrotic leaves usually drop prematurely, leaving only a few withered remnants attached to the stems. Wilted stems usually show vascular bundle discolouration (5). Tubers can also become infected, with resultant light brown discolouration of the vascular tissue. Microsclerotia (small black walled structures) are formed in dying tissue and are often visible with low magnification (6). Microsclerotia are not always visible on infected tissue, however.



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