

VIRUS DISEASES AND APHIDS



potatoes
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VIRAL DISEASES

Viruses use plants and animals as hosts, causing diseases in both. The major difference between animals and plants is that an animal's immune system actively combats the virus through white blood cells and can thus bring it under control. A plant's immune system is incapable of controlling the virus, and once infected it remains so for the duration of its lifetime. Moreover, there is no plant protection product available to control viruses in plants.

Potato viruses can be effectively controlled by means of the measures put in place through certification schemes. The success of a certification scheme depends on the ability to detect the symptoms of viral infection or to accurately test for the presence of a virus, the implementation and maintenance of strict tolerances, the discipline of seed potato growers in terms of planting only certified seed potatoes, and the effective control of the vectors.

Although there are approximately 25 viruses that occur in potatoes, there are two viruses of particular economic importance in South Africa, namely Potato Virus Y (PVY) and Potato Leafroll Virus (PLRV). Tomato Spotted Wilt Virus can be a problem from time to time, and Calico Virus occurs in regions where lucerne is cultivated. This fact sheet focuses on the management of PVY and PLRV.

Why is it so difficult to control viruses in seed potatoes in South Africa?

While virus control may seem simple in principle (combat the source and spread of virus vectors, and combat the source and spread of viruses), this is easier said than done, for the following reasons:

- The majority of production regions do not experience harsh winters. One or more winter crops are still planted, while home and city gardens are kept green. This provides a constant source of hosts for both viruses and aphids. If the winter is not cold enough, the aphid population is not sufficiently reduced and can rapidly repopulate at the start of the season.
- Potato production occurs throughout the year in some regions. This makes it extremely difficult to combat the source of viruses (infected plants) and the spread thereof by aphids.
- In South Africa, there are no longer specific areas that are limited to the production of seed potatoes, and in most regions there are no obligatory haulm killing dates.
- Potatoes are produced at different times of the year, and seed potatoes must be available throughout the year. As a result, certification is becoming ever more reliant on testing, since the virus symptoms are not always visible or recognisable.

THE DISEASE TRIANGLE

Plant

- Virus infection can reduce yield by up to 90%
- Some cultivars are more attractive to aphids than others
- Certain cultivars are PVY and/or PLRV tolerant
- There are numerous host plants for PVY
- PLRV hosts are primarily of the Solanaceae family
- The appearance of virus symptoms varies, depending on the cultivar, growth stage, and stage of infection



Aphids

- About 8 aphid species are important vectors for PVY and PLRV in South Africa
- Reproduction is mainly asexual and rapid
- Winged aphids fly short distances between plants and adjoining fields
- Winged aphids can also travel hundreds of kilometres via air currents from one region to another
- Wingless aphids can move up to 8 m in a field per day
- Aphids have a wide range of hosts

Virus

- PVY and PLRV are the most significant viruses affecting potatoes in South Africa
- Spread mainly through infected seed potatoes and aphids
- PVY can occur in every cell in plants and is spread by aphids in a non-persistent manner
- PLRV is limited to phloem tissue and is spread in a persistent manner by aphids
- There are no chemicals available that can be used to control the virus

MANAGING THE RISK OF VIRUS DISEASES AND APHIDS

	RISK	MANAGEMENT
PRODUCTION REGION	Host plants are cultivated year-round in a region	<ul style="list-style-type: none"> - Develop a control strategy with which all farmers in the district must comply. - If this is not possible, each and every farmer will have to implement extremely strict control measures.
	Seed- and ware potatoes are being planted less than 500 m apart	<ul style="list-style-type: none"> - Proper aphid control in ware potato fields is essential. - See to it that only certified seed potatoes of a low generation and low virus content are planted in ware potato fields. Consider supplying certified seed potatoes with low virus content to commercial and small-scale farmers as a means of reducing viral pressure.
TIME OF PLANTING	Aphids usually occur during the normal planting season	<ul style="list-style-type: none"> - Consider adjusting the time of planting. - If this is not possible, a strict control programme must be followed.
	Dry and hot time of the year	<ul style="list-style-type: none"> - Consider planting at a different time of the year, since aphids reproduce rapidly in hot, dry weather.
	Commercial host crops are still in production in the region at the time of planting seed potatoes	<ul style="list-style-type: none"> - Strive to clear all commercial crops from the land before planting seed potatoes. - Otherwise a timely and strict aphid-control programme is a necessity.
CHOICE OF LAND	Volunteer plants, weeds and other host plants, as well as table potatoes, are found within 500 m of the seed potato planting.	<ul style="list-style-type: none"> - See to it that the environment is kept free from all host plants and aphids. - Consider implementing a management plan for the entire region.
	Seed potato plantings are downwind from plantings of other host plants	<ul style="list-style-type: none"> - Consider planting upwind from other host plants.
CHOICE OF CULTIVAR	Cultivars that are attractive to aphids are planted	<ul style="list-style-type: none"> - Ask the supplier of the cultivar for more information, since this will aid in the management process. - Your own observations can be made by using yellow bucket traps in the fields of different cultivars and monitoring the incidence of aphids.
	Cultivars that are tolerant to virus infection are planted	<ul style="list-style-type: none"> - Ensure that rogueing is done with great care, since tolerant cultivars may show no, or mild symptoms. - Consider the testing of leaf samples by means of rt-PCR to allow for a timely decision on the utilisation of a planting. Discuss your intentions ahead of time with the PCS inspector or the laboratory. - For the producers of ware potatoes, tolerant cultivars are beneficial, since crop losses are reduced compared to sensitive cultivars.

MANAGING THE RISK OF VIRUS DISEASES AND APHIDS

	RISK	MANAGEMENT
SEED POTATOES	Uncertified seed potatoes are planted	<ul style="list-style-type: none"> - Plant only certified seed potatoes, since more is known about the risk of viruses in these plants.
	Tubers are cut	<ul style="list-style-type: none"> - Preferably purchase small seed potatoes, or ensure that the highest standards of sanitation are maintained while cutting, since PVY is easily spread through plant sap from an infected tuber to others.
	Seed potatoes are cultivated in regions where there is a risk of late season infection	<ul style="list-style-type: none"> - Ask your supplier for the post-control report, but if this is unavailable, decide whether the risk is worthwhile. - Consider testing of seed potatoes by means of rt-PCR technology in order to identify latent late-season infection.
CROP MAINTENANCE	Aphid monitoring shows that aphids are present early in the season	<ul style="list-style-type: none"> - Other host plants in the vicinity must be removed. - Chemical control must be applied diligently. - See to it that all other elements of the control programme are implemented with diligence.
	Other host plants in the vicinity go into decline or are harvested	<ul style="list-style-type: none"> - Any aphids that were present in those fields will migrate to the seed potato field, since it is green and thus attracts them. - Maintain a strict control programme.
	The virus spreads from infected plants in the planting to other plants	<ul style="list-style-type: none"> - Proper rogueing is effective in combating the spread of PLRV in particular. - Rogueing is less effective to limit the spread of PVY because symptoms can be difficult to recognise.
	Late season aphid activity	<ul style="list-style-type: none"> - Plants can be infected with the virus as long as they are green so do not cease aphid control towards the end of the season. - Do not make use of systemic aphid chemicals where plants are showing signs of stress, since the chemical would be less effective at that stage. - Consider having a leaf sample or the seed potatoes tested by means of rt-PCR for the presence of a virus, since plants that are infected late in the season often do not show symptoms.
HAULM KILLING	Regrowth of haulms	<ul style="list-style-type: none"> - Haulm killing must be done in the shortest possible time to avoid potential late season infection. - Remove regrowth and prevent further growth. - Maintain a strict aphid control programme, as plants could still be infected with the virus, without being detected by the ELISA test. - Consider having samples tested by means of rt-PCR.
STORAGE	Aphids spread the virus from infected seed potatoes	<ul style="list-style-type: none"> - Where seed potatoes that are starting to sprout are kept in an open storage facility, they could still be visited by aphids and become infected. Make use of yellow bucket traps to monitor aphids, and spray plants immediately with a suitable aphicide.

DAMAGE

Yield losses due to virus infection is caused by a reduction in the number and size of tubers, as well as quality and can range from 10 - 90%. Some strains of PVY, such as PVY^{NTN}, PVY^N and PVY^{WILGA} cause necrotic ringspot on the tubers of certain cultivars and can lead to downgrading on the market. The planting of infected tubers usually results in far more serious damage than is the case when plants are infected during the growing season. It has been found that where PVA or PVX occurs in combination

with PVY in plants, the damage is more severe than in the case of tubers infected with PVY only.

Although aphids are synonymous with the spread of PVY and PLRV, they are seldom the direct cause of major damage to crops.

VIRUSES

A virus is the “ultimate” parasite

A virus consists of only the genetic information for its composition and the protective covering (coat, or capsid protein), and it makes use of other organisms to spread, to penetrate its host and to reproduce. Virions are invisible to the naked eye, and are in fact so small that they are visible only under an electron microscope. Viruses are obligate parasites, meaning that they are able to reproduce only in the cells of their host plant, because they are composed of only DNA or RNA plus a protective layer. The diseases and symptoms caused by viruses are usually the only visible indication of their presence in plants.

PVY occurs throughout the world, and many different strains and isolates exist. In 2005, researchers at Stellenbosch University confirmed the presence of the tuber necrotic strains (PVY^{NTN}, PVY^N and PVY^{WILGA}) in South Africa. Necrotic strains are currently the most significant PVY strains in South Africa. One of the characteristics of the NTN strain is that infected plants are often symptomless, or show only very mild symptoms. This complicates management since infected plants are not always identified during roguing. This is a particular problem where a cultivar is also tolerant to PVY^{NTN}. PLRV has less variation than PVY and symptoms are normally easily recognized.

Hosts. Leafroll hosts are mostly limited to the Solanaceae family. In contrast, there are approximately nine plant families that serve as hosts to PVY, including 14 genera van die Solanaceae family, for example: tomatoes, peppers (chillies, sweet peppers, paprika, etc.) and tobacco, as well as several weed species of such as the large thorn apple and nightshade.

Virus detection

Since symptoms are sometimes unrecognisable or absent due to latent infection, tests are used to more accurately determine whether plants are infected with a virus. There are several different tests available, each with its own *benefits, limitations* and *cost*. The choice of which test, methods and processes to use depends on the extent of the virus detection, the cost of the test, the application of the results, and the plant material to be tested.

The visible symptoms on an infected plant are the result of the virus penetrating the plant cells and “hijacking” their physiology, causing the plant cells to reproduce the virions instead of performing its normal functions. The effect can manifest in different ways, depending on:

- the virus (and sometimes also the specific strain or isolate),
- the potato cultivar,
- climate and
- the age of the plant, as well as the growth stage at which the plant became infected.

When a plant is infected with more than one virus, the symptoms differ from those that occur when a single virus is involved.

The terms **primary** and **secondary infection** are used to differentiate between infection from the previous season (secondary infection) and infection in the current season (primary infection). In the case of secondary infection, infected seed potatoes are planted, while primary infection involved uninfected plants being infected during the current growing season. Secondary infection is indicated by symptoms on the oldest leaves, whereas primary infection is indicated by symptoms on the youngest leaves.

Although visible symptoms are not always present for the identification of a virus, they play an important role in recognising infected plants within a field so that they can be removed in an effort to reduce virus pressure.

Mosaic and rugose mosaic patterns as well as necrosis symptoms are associated with PVY infection. Symptoms of PVY can be evident as soon as 10 days after infection, but this could take longer. The appearance of symptoms is determined by the cultivar, climate, age of the plant, and virus strain. Symptoms can therefore vary from one year to the next and from one



cultivar to another. Leaf symptoms of the necrotic strains of PVY are often less prominent and not easily recognisable. There are certain cultivars that are tolerant to PVY and suppress the appearance of symptoms. This can hinder roguing, since the absence of visual symptoms is not an indication that no virus is present.

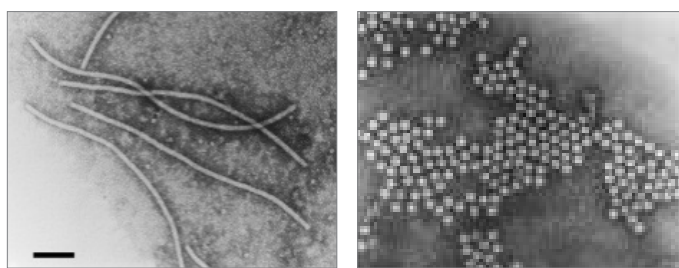
Symptoms of necrotic PVY strains on tubers can be prominent and result in the downgrading.

Upward rolling of leaves are associated with PLRV infection. Infected leaves may later become slightly yellow and leaves of some cultivars may also turn reddish or pink. Leaves of some cultivars roll only at the bases of the leaves. As mentioned, symptoms vary depending on the virus strain or isolate, the host, the climate, and the growth stage of the host plant.



Biotesting was one of the first techniques developed to isolate and identify viruses. This type of test, based on the so-called Koch postulate, is relatively simple in principle and involves the inoculation of a panel of host plants with a particular virus. The virus is then identified on the basis of the appearance of symptoms on the host plant. The disadvantage of this test is that it must be carried out in a facility with guaranteed biosecurity, making it totally impractical for the purpose of determining the number of infected plants within a field.

Electron microscopic. Virus particles are visible under an electron microscope (EM), since it has the ability to magnify virions ten thousand times. Virion size is measured in nanometres (1 nanometre = 1×10^{-9} metres). Prior to the commercial use of serological tests, the EM played an important role in the identification of viruses in agricultural crops, and it remains a valuable tool in virus research.



Serological tests (ELISA). Serological tests are based on the principle that the coat protein of the virus is recognised by the antibodies produced by mammals, and bind with them. The test is designed to enable visual detection of the bond between coat protein and antibody and is seen as discoloured pits on an ELISA slide. This is the test most commonly used around the world, due to the cost benefits and simplicity of execution.

The ELISA test used by Potato Laboratory Services can detect all strains of both PVY and PLRV known to occur in South Africa.

The advantage of the ELISA test lies in the fact that it is relatively inexpensive, while it allows for the testing of a large number



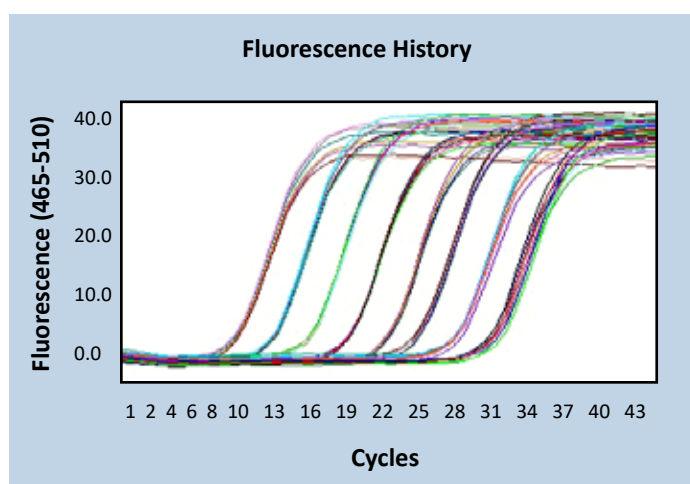
of samples in a small laboratory, and the execution thereof is reasonably robust.

The ELISA test is limited in the sense that it is unable to detect very low levels of viral infection, as in the case of primary infection late in the season. The test is also insufficiently sensitive for the detection of viruses in fresh seed potatoes which is caused by the properties of the potato plant, the virions, as well as the host-virus interaction.

Research has shown that the test can only be performed once the resting period is over for all seed potatoes in the sample and they have started sprouting. In the case of long-season cultivars, this could take much longer than 28 days, while for short-season cultivars it could take less time than 28 days.

Molecular tests (rt-PCR). This test ‘sees’ the DNA or RNA of viruses and can be designed to be highly specific and sensitive. In 2015, the rt-PCR test was approved for use in the South African Seed Potato Certification Scheme. The sensitivity of the test is based on the fact that the DNA or RNA is recognised by primers and then multiplied so that they may be detected by means of specific probes. The test gives an indication of the presence and level of the sample’s virus content.

Due to the sensitivity of the test, it has the ability to detect small quantities of a virus – also in fresh tubers and recently infected leaves. Results are available shortly after harvest. The disadvantage of the test currently, is that it is relatively expensive, that the laboratory has to be specially equipped for PCR, and the technologist must be trained in the testing procedure.



Spreading of the virus

Seed potatoes are the most significant method in which viruses are spread from one production region to another, and even from one continent to another. This, together with the detrimental effect of viruses on yield, is the reason why most countries have established certification schemes.



Aphid vectors. The virus particles themselves do not have the ability to spread on their own or to penetrate host plants. Viruses make use of vectors to perform those functions for them, and the relationship between virus and vector is specialised and specific. Aphids serve as vectors for both PVY and PLRV, but the way in which these two viruses are spread from one plant to another differs significantly.



PVY is transmitted in a non-persistent manner by aphids. An aphid that lands on a leaf, first tests whether the plant is a suitable host by piercing the epidermal cells with its mouthparts and tasting the sap before feeding. If the plant cell is infected with PVY, the viruses are ingested together with the plant sap and remain in the mouthparts of the aphid. When the aphid lands on another plant and again tastes the sap, the virus is spread to those other cells.

Due to the fact that the ingestion and transmission of the virus by aphids can occur within a short period of time (<60 seconds), and the aphid remains infectious for a limited time, PVY is spread mainly by visiting aphids (aphids searching for a suitable host).

An infected aphid remains infected for no longer than 24 hours and the virus is not transmitted to the offspring.

Leafroll virus is spread in a persistent manner by aphids. PLRV occurs only in the phloem vessel cells of plants, while the aphid vectors feed on the plant sap in the phloem vessels. When an aphid finds a suitable plant, it moves its mouthparts (stylet) in between the leaf cells until it reaches the phloem cells. The aphid then feeds for a period of 15 minutes or longer, ingesting the virus particles along with the plant sap. The virus particles then make their way to the aphid's stomach and are circulated through the gut of the insect. During this period of approximately 8 - 24 hours, the aphid is not able to transmit the virus to another plant. After circulating through the aphid's body, the virus reaches the aphid's salivary glands and can then be transmitted to another plant. Once the virus has established itself in the digestive tract of the aphid, the infected insect is capable of spreading leafroll virus for the remainder of its life. PLRV is not transmitted to the offspring. The virus reproduces in phloem cells and moves through the phloem vessels to other parts of the plant.

Due to the fact that the ingestion, circulation and transmission of the virus take a relatively long time, aphids feeding on potato plants act as the vectors for the leafroll virus.

Plant sap. *The spread of PVY through plant sap* is possible if fresh sap is transmitted to an open wound on the plant since any plant cell is receptive to the virus. Large insects such as beetles that feed on infected plants can spread the virus through plant sap to other plants. Plant sap clinging to implements during irrigation, spraying, etc. also serve to spread the virus. PVY can also be spread through human activity, and by animals walking through a field and rubbing up against the leaves. The cutting of tubers can cause a significant increase in the percentage of tubers with secondary infection, since sap clinging to the blades

is transmitted to other tubers. The handling of infected tubers (removal of sprouts manually or with brushing machines) can also lead to the virus being spread through sap.

The spread of leafroll virus through plant sap is impossible, as the virus is limited to the phloem vessels in plants. Researchers make use of inoculation or infected aphids when transmitting leafroll virus to a plant.

Can PVY and PLRV be spread by other insects besides aphids?

As already mentioned, large chewing insects can spread PVY through plant sap. PVY cannot be transmitted coincidentally by other sucking insects, since transmission is not a coincidental process. PVY virus particles remain in the mouthparts of aphids because there are *vector-specific factors in the saliva or on the stylet of the aphids that are involved in the process.*

Leafroll virus is ingested along with the plant sap from the phloem vessels by vectors and is then spread. Insects that do not share the same feeding method are thus incapable of ingesting the virus. Moreover, the virus has a highly specialised relationship with vectors, since the virus binds with unique receptors in the digestive tract, allowing it to circulate through the aphid.

Spreading of the virus in the potato plant. Should PVY find its way into a cell of a host plant, the virus reproduces inside the cell and is then spread by plasmodesmata (channels in the cell walls) to other cells, ultimately infecting the entire plant. The virus can occur in large numbers in plant cells, particularly in the epidermal cells and glandular hairs. It is these same cells that are tested by visiting aphids and which are damaged when plants rub up against one another, or when humans or animals walk amongst the plants. When infected plants start declining, the virus is transported along with nutrients in the plant sap to the tubers. According to research done at Stellenbosch University, PVY^{NTN} spreads at different rates in different cultivars (Table 1).

Leafroll virus reproduces in phloem cells of the vascular tissue and is spread through the phloem vessels to different plant parts. Vascular tissue in a particular leaf is continuous with vascular tissue on a specific side of a haulm and eventually ends up in specific tubers of the haulm. This explains why not all the tubers from an infected plant are necessarily infected with leafroll, or have a very low virus titre. Due to the fact that leafroll virus occurs only in phloem, fewer virus particles occur in plants than in the case of PVY.

Table 1. The difference in the speed with which PVY^{NTN} moves within plants of different cultivars, and the occurrence of tuber necrosis (Bellstedt, 2016).

Cultivar	The number of weeks required by virus to move from one leaf to the next	Average % of tubers with tuber neurosis
Valor	4.50	3.57
Fiana	4.44	15.10
Innovator	3.62	0.00
Lanorma	3.75	0.00
Up-to-Date	3.88	15.10
Vanderplank	3.83	15.33
Avalanche	3.00	0.00
Sifra	4.00	22.00
Eos	2.50	0.00
BP1	2.80	17.29
Hermes	2.00	25.80
Mondial	2.27	58.30

APHIDS

Vector species in South Africa

To date, 21 aphid species, including species groups, have been identified as PVY vectors in South Africa. Data gathered from suction traps and yellow bucket traps over the past 10 years

in four seed potato production regions has identified eight prevalent aphid vectors. The most common vectors differ per production region, depending on the types of crops planted in the area, as well as the climate (Table 2).

Table 2. Plant aphid species that are vectors of PVY and PLRV, and their spread in different regions.

Aphid species	PVY-vector	PLRV-vector	Most significant aphid species per region			
			KwaZulu-Natal	Ceres	Sandveld	Western Free State
<i>Acyrtosiphom pisum</i> (pea aphid)	o				••	
<i>Aphis gossypii</i> (cotton aphid)	o	o	••			••
other <i>Aphis</i> species	o	o	••			
<i>Macrosiphum euphorbiae</i> (potato aphid)	o	o		••	••	
<i>Myzes persicae</i> (peach aphid)	o	o		••	••	
<i>Metopolophium dirhodum</i> (rose-grain aphid)	o				••	
<i>Rhopalosiphum padi</i> (cherry-oat aphid)	o		••			•••
<i>Sitobion avenae</i> (grain aphid)	o				••	

Biology of aphids

In countries that experience cold winters, aphids survive mainly as eggs. Locally, adult aphids hide on plants, for instance in the axillary buds. When the temperature rises in the spring, the aphids give asexual birth to many wingless female aphids. The wingless colony reproduces until the population level becomes too high in a particular location. Winged individuals are then born, and a percentage of the colony flies over short distances to other plants in a field, or they fly high up into the air where they are carried by air currents and wind over long distances to other farms or other regions. Such aphids are known as migrants.

The effect of climate on aphids

Long-term monitoring in the Sandveld by the Western Cape Department of Agriculture revealed that vector pressure is reduced following high rainfall, as the aphids are physically washed away from the plant surface, while rainfall is typically accompanied by low temperatures (Figure 1).

How do aphids choose where to feed?

Aphids that are carried by air currents towards a potato field are not capable of identifying their preferred hosts from the air. Aphids are attracted by colour contrast. They therefore tend to settle around the edges of fields, in spray paths and open furrows.

Due to prevailing wind directions, emigrating aphids may tend to settle on one particular side of a potato field.

Preference for specific host plants

Research at the University of Pretoria found that alate individuals of *Rhopalosiphum padi* has a preference for yellow and lime green. Potato plants with a naturally lighter green colour, plants with a nutrient deficiency or symptoms of disease, or plants that are in decline, will most likely attract aphids before plants of a darker green colour. Aphids also distinguish between plants on the basis of the odours they emit.

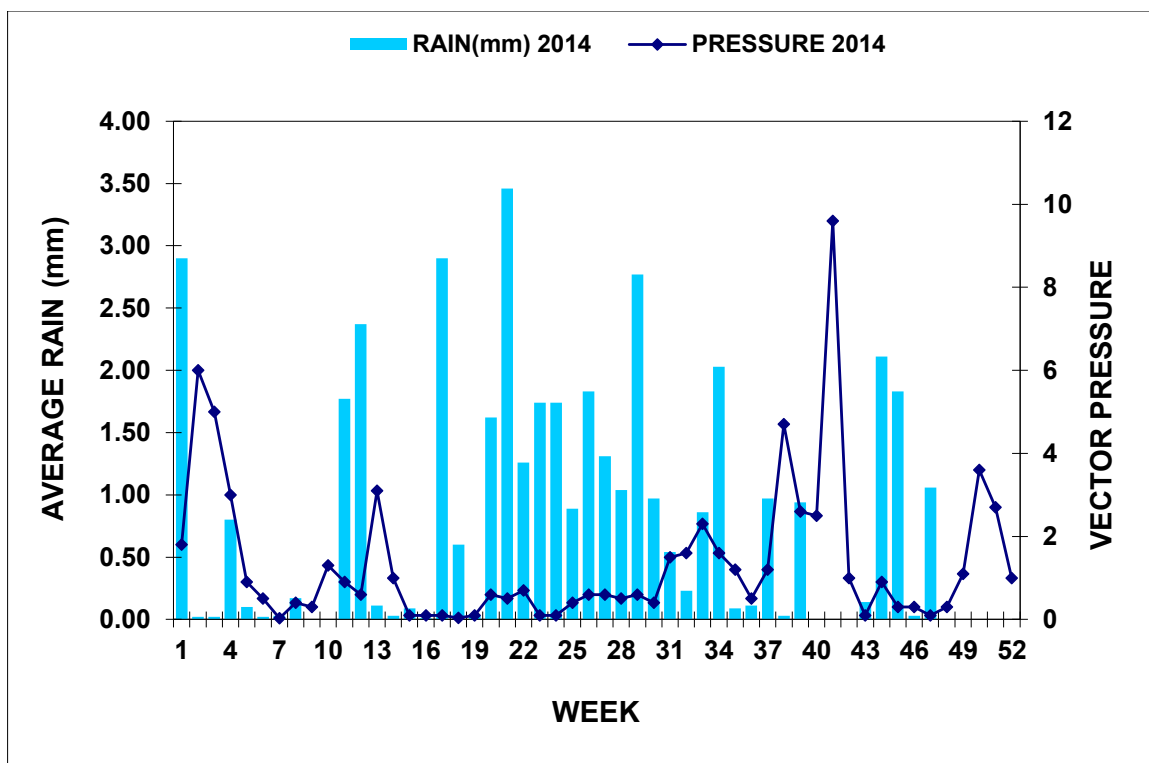


Figure 1. Rainfall and vector pressure per week in the Sandveld in 2014.

MANAGEMENT OF VIRUS DISEASES

Virus management is based on two principles:

- Combating the source and spread of aphids (virus vectors);
- Combating the source and spread of viruses.

Combating the source and spread of aphids (virus vectors)

Aphid management is a numbers game. The aphid lifecycle can be as brief as 7-10 days and each female can give birth to many offspring. Under favourable climatic conditions, an aphid population can double within 2 days. If aphid populations are allowed to develop within a field, total control is virtually impossible.

If only one aphid occurs per square meter of a field under optimal conditions, no aphid control is applied, and each individual aphid gives birth to about 50 offspring, then the population of aphids per square meter can increase to 250 in just two weeks. It is thus important to leave no gaps in the programme.

“To measure is to know”. Aphid monitoring is of cardinal importance in helping to identify aphid flight patterns or the presence of aphids on a piece of land. By the time aphids are visible when walking through the fields, it is already too late, as large numbers of aphids are already present on the plants. The producer must make use of yellow bucket traps to get an indication of the aphid pressure in a field. Suction-trap data is used to determine the flight patterns in the region, as well as the effect of climate.

Insecticides are indispensable in the control of aphids, but their use is but one element of the management programme and must be used with due care in order to prevent resistance to chemicals. According to recent research results from the Agricultural Research Council, 16 aphid species (including *Myzes persicae*, *Macrosiphum euphorbiae* and *Aphis gossypii*) have not developed resistance to registered aphid chemicals (endosulfan, acephate, profenofos, dimethoate and metamidofos) in South Africa.

Where spraying programmes appear ineffective, factors such as application technology, time of day at which spraying occurs and the mixtures being used, should be investigated.

Where the aphid pressure in the area is very high, it is extremely difficult to control aphids by means of insecticides only.

Systemic chemicals applied into the soil can effectively control aphids by combating population growth early in the season. This is an effective means of controlling the spread of leafroll, which

is spread in a persistent manner. However, it is not effective in controlling the spread of PVY, which can be spread in a non-persistent manner within a few seconds as the aphid searches for a suitable host, before it can be killed by the chemical.

Research has shown that the presence of plant protection chemicals on the leaf surface can cause an increase in the number of times an aphid tastes the cells, since the chemical is an irritant to them and they continue searching for a suitable cell on which to feed.

Application of insecticides. Aphids usually hide on the underside of leaves. There is usually good coverage in the upper parts of the leaf canopy, but poor coverage in the lower parts. Since registered sprays are classified as either contact or systemic/translaminar, it is important that the chemicals reach all the leaves at the bottom and in the centre of the plant. Effective results are achieved with the application of insecticides by means of boom sprayers when there is no wind and the temperature is cooler.

It is important to always follow the manufacturer's instructions.

Aphid monitoring

An aphid monitoring network has been initiated in 2005 by Potatoes South Africa, The University of Pretoria and Western Cape Department of Agriculture. There are currently nine suction traps in five seed production regions, viz Sandveld, Ceres, Douglas, Western Free State, and KwaZulu-Natal. The data is used to identify times of the year when the risk of virus transmission in a specific region is high. This information is used to plan planting times and aphid control. The value of aphid monitoring is evident only after a few years of monitoring.

Figure 2 gives data generated over a period of 8 years in the Western Free State. In this case, aphid flights occur twice every year, first during October and then during January/February. In this region, the intensity of the flights of all aphid species varies from year to year (A) and the the pressure of vectors of PVY (B) is higher than the pressure of vectors of PLRV (C).

Figure 3 illustrates the variation in cumulative vector pressure of PVY (A) and of PLRV (B) from one year to the other. The vector pressure in the seasons of 2008/9; 2010/11 and 2013/14, was higher than in other years. Aphid flights early in the season have significant effect on vector pressure later in the same season.

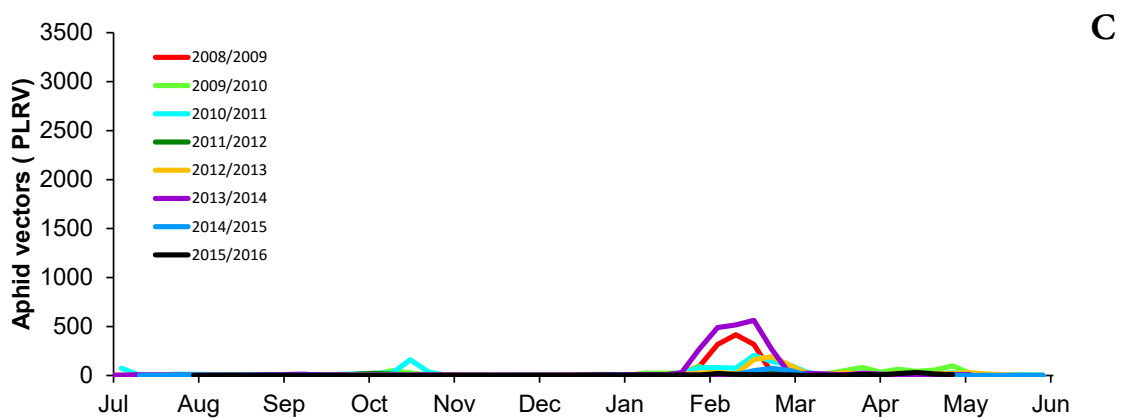
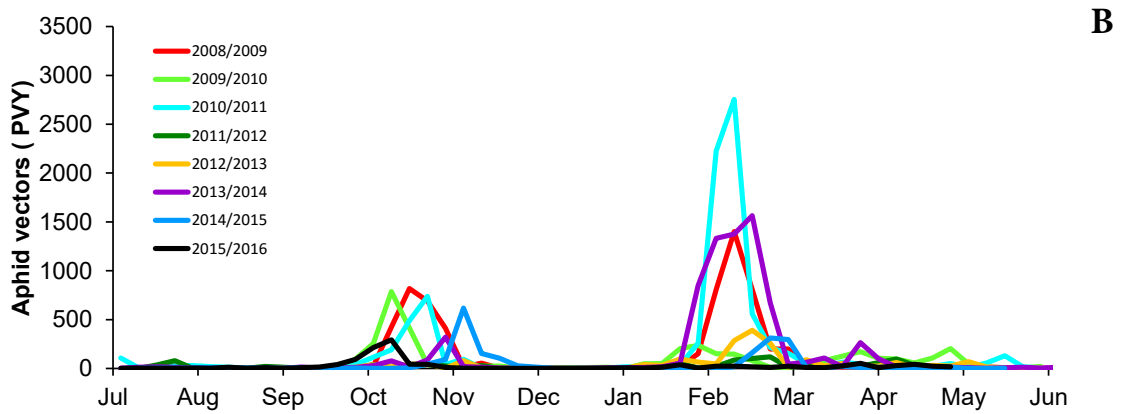
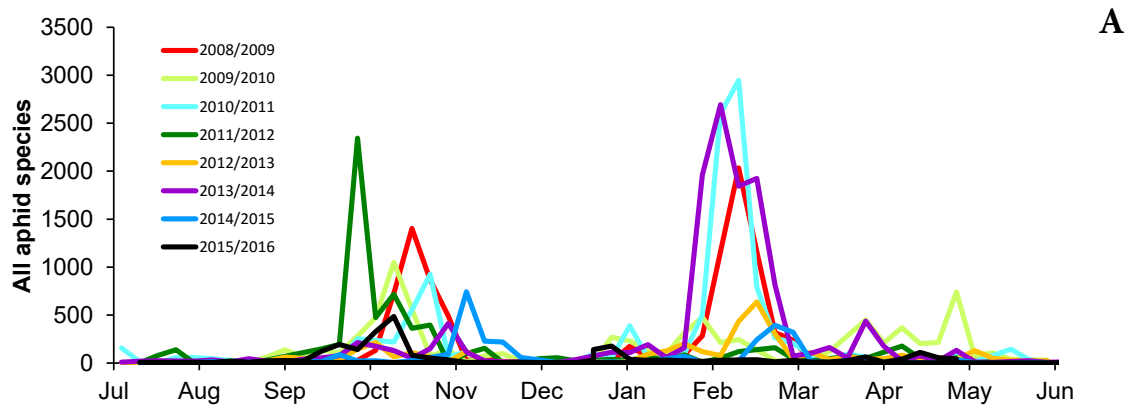


Figure 2. The number of aphids caught in the suction trap in the Western Free State over a period of eight years. A: all aphids, B: vectors of PVY and C: vectors of potato leafroll virus.

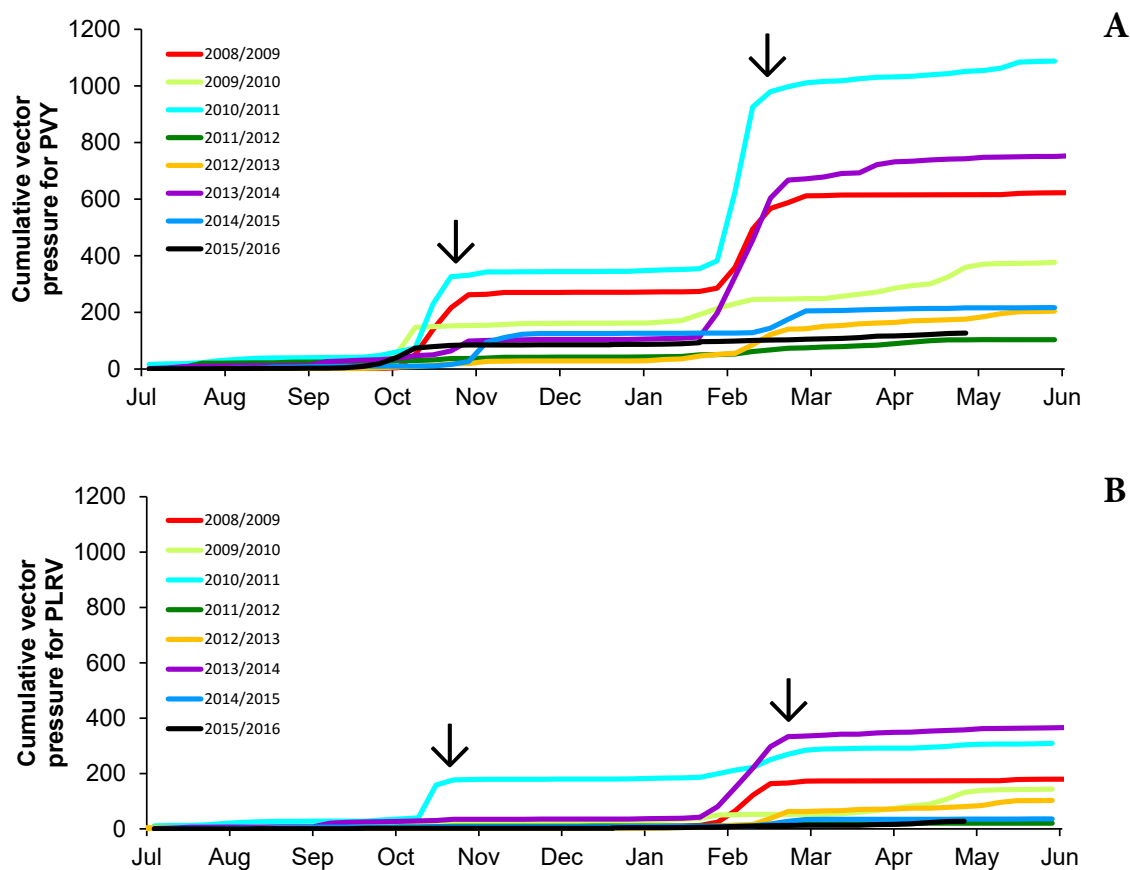


Figure 3. The cumulative vector pressure for PVY vectors (A) and potato leafroll virus (B) for an 8 year period in the Western Free State.

Combating the source and spread of the virus

The most obvious means of combating the spread of a virus is by planting seed potatoes with no or very low virus content. Where other sources of a virus are present in the vicinity, however, the field can quickly become infected due to the efficiency with which aphids spread and carry the virus from one plant to another.

- Important sources of potato viruses are volunteer plants, table-potato fields and weeds.
- Seed potato fields, particularly those of low generation, should be situated as far away as possible from fields of ware potatoes, but at least 500 m away.
- Volunteer plants and weeds in and around seed potato fields must be strictly controlled, starting before any seed potatoes are planted.

Management of virus diseases in South Africa

Due to our unique situation, it is of cardinal importance that a strict management plan is implemented with great discipline:

- Only certified seed potatoes of a low generation and low virus content should be planted in a seed-potato production

region, following the release of the post-control results.

- Seed potatoes should be planted at times when aphid populations are low.
- Seed potato plantings should be killed off before the vector pressure is high.
- Aphids must be monitored. Suction trap data provides information on aphids in a particular region, while yellow bucket traps provide information on the presence of aphids on the seed potato farm and in seed potato fields.
- Volunteer potatoes, weeds and other host plants must be strictly controlled in order to reduce the source of the virus and its vectors in the region.
- The proper roguing of fields is essential to prevent the source from occurring within the field.
- Testing for viruses as part of the certification process must be accurate within the limitations of the test, with adjustments according to the circumstances. For this reason, the testing protocol of Potato Laboratory Services sets strict provisions in terms of when seed potatoes are considered test-ready, e.g. all eyes on the tuber must have sprouted.

SYMPTOMS OF ALAFALFA VIRUS



The most common symptom of alfalfa virus is light (1) to bright yellow (2) lesions on leaves.

SYMPTOMS OF TOMATO SPOTTED WILT VIRUS (TSWV)



Symptoms of tomato spotted wilt virus are affected by cultivar and the age of the potato plant when it is infected. Lesions on leaves vary from a single necrotic ring (1) to concentric necrotic rings. Symptoms include necrotic lesions on leaves (2) and sometimes the whole plant dies.

Read further:

CHIPS ARTICLES (www.potatoes.co.za/research/Chips-articles)

D Bellstedt, C Visser & W Roos. 2013 Navorsing oor PVY rasse in Suid Afrika. Chips Nov/Dec 2013.

D Bellstedt, C Visser, W Roos & C de Villiers. 2016. Die beheer van Mosaïek virus infeksies in aartappels in Suid-Afrika: die rol van weerstandbiedende aartappelkultivars. Chips May/Jun 2016.

A Espach. 2011. Virus content of seed potatoes. Are we doing the right thing in combining the total virus content of seed potatoes for certification? Chips Sep/Oct 2011.

A Espach. 2013. Can a leaf sample from a field planting be considered as an official sample in the certification process? Chips Jan/Feb 2013.

K Krüger. 2015. The value of aphid monitoring in South Africa. Chips Sep/Oct 2015.

K Krüger, K Laubscher. 2012. The South African aphid monitoring network. Chips May/Jun 2012.

JM Laubscher. 2012. Plantluis beheer tydens moerproduksie. Chips Jul/Aug 2012.

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D Moller. 2016. Aartappelrolbladvirus: primêre of sekondêre infeksie? Chips Jan/Feb 2016.

P Nortjé. 2005. Bestuur van die virusprobleem. Chips May/Jun 2005.

F Venter & K Krüger. 2014. Aphid transmission of Potato virus Y in South Africa. Chips Jan/Feb 2014.

FINAL REPORTS (www.potatoes.co.za/research/final-reports)

D Visser, & D Majola. 2010. Investigation into insecticidal efficacy against aphids occurring in potatoes.

K Krüger, M Robertson, JM Laubscher, ML Schröder, I Millar & L Muller. Aphid monitoring in the South African potato industry.

K Krüger, M Robertson, M Warren, ML Fourie & I Millar. 2014 Management of Potato virus Y (PVY) in seed potatoes.

SYMPTOMS OF POTATO VIRUS Y (PVY)



Mosaic symptoms of PVY on leaves (1, 2, 3). Typical symptoms of PVY^o (4). Tuber necrosis caused by PVY^{NTM} (5, 6).



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SYMPTOMS OF POTATO LEAFROLL VIRUS (PLRV)



A plant showing symptoms of secondary infection (1). Symptoms of primary infection with leaves showing slight rolling (2) and clearly recognisable symptoms of primary infection (3, 4, 5)

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