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ARC-Vegetable, Industrial and Medicinal Plants Newsletter

Newsletter of the Vegetable, Industrial and Medicinal Plants, campus in the Crop Sciences Programme of the Agricultural Research Council (ARC)

DNA profiling to determine the genetic diversity of cannabis

Compiled by Inge Gazendam, Willem Jansen van Rensburg, Stephen Amoo and Ian du Plooy

What?

South Africa has a rich reservoir of local cannabis varieties and landraces. Little is known and documented on the diversity that exists within and between them. The ARC-VIMP has embarked on applying DNA profiling techniques to characterize and document the genetic diversity of available cannabis strains and landraces.

Why?

There is a need for DNA characterization in the medicinal plant industry since some species (and their strains) suffer from intentional adulteration, and incorrect identification perhaps due to various names being used for the same strains. The same landrace can have different names in different regions or different landraces can have the same name. There may also be a divergence within a single landrace if it is maintained by different knowledge holders. Strategies need to be devised to identify and describe a specific landrace and such identified landraces need to be conserved appropriately to maintain their genetic integrity. The correct reference strain needs to be determined for a specific landrace.

Cannabis is wind pollinated, so the seeds collected from a mother plant are not uniform. The ARC previously detected variations within landraces when applying the International Union for the Protection of New Varieties of Plants (UPOV) agro-morphological descriptors. The diversity can be seen in a cannabis variety trial illustrated in Fig. 1. Keeping strains and culti-

Figure 1. Cannabis variety trial used to characterize the ARC-VIMP cannabis landrace collection using UPOV agro-morphological descriptors (Photo by Mr KN Mokgohloa).

vars pure is therefore an important aspect of developing the commercial medicinal cannabis industry in South Africa. The genetic integrity of the local cannabis strains and landraces (some of which may be of superior quality for different purposes) can potentially be threatened by the influx of foreign cannabis strains. Since the UPOV morphological descriptors were not robust enough to sufficiently discriminate between the different landraces, or to determine the diversity within a landrace, the application of molecular markers was recommended in order to have a higher discrimination ability for better establishment of variation within landraces.

How?

Our laboratory at the ARC-VIMP is equipped to perform genotyping on a DNA level using various molecular markers such as simple sequence repeats (SSR) (also called short tandem repeats (STR)), single nucleotide polymorphisms (SNP) and others. Only a small sample of fresh leaf material is needed to extract genomic DNA. Seven of the SSR markers of a published set of 13 commonly used for forensic *Cannabis sativa* DNA profiling (Houston et al., 2017) are currently applied as a multiplex to save costs. The fluorescently labelled amplified products are separated by capillary electrophoresis, whereafter the peaks are scored into different sized alleles for each marker. An example of the typical peaks obtained for a diploid cannabis sample is presented in Fig. 2.

Results

A cannabis accession database has been set up to document the DNA profiles and all other information linked to an accession as it is characterized further. The genetic relationships between a portion of the ARC-VIMP's cannabis collection, compared to a few client samples, are presented visually in the form of a dendrogram (Fig. 3). The application of seven SSR markers were able to show differences between all accessions except landraces 25 and 29, which were identical. Clear distinctions could be made between the different types of accessions (landraces, commercial cultivars for medicinal use, fibre), emphasizing the value of the SSR panel. It is noteworthy that landrace strain 18 was derived from a commercial strain mother plant but may have crossed with an unknown pollen parent.

Going forward

We are interested in complementing the molecular/genotypic profiles with chemical analysis to determine the cannabis strains' phytochemical and biological properties. The database needs to grow with verified strains to provide more useful information. We intend to increase the SSR marker panel to the full set of 13 SSR markers supported by literature. We also want to start applying sex-determining genotypic markers, since according to our experience, there are no reliable phenotypic markers to identify a male or female plant at the seedling stage. We therefore invite requests from the cannabis industry to have their strains DNA profiled for legal protection, among other purposes, and to assist in their breeding efforts.

Reference

Houston R., Birck M., Hughes-Stamm S. & Gangitano D. 2017. Developmental and internal validation of a novel 13 loci STR multiplex method for *Cannabis sativa* DNA profiling. *Legal Medicine* 26: 33-40.

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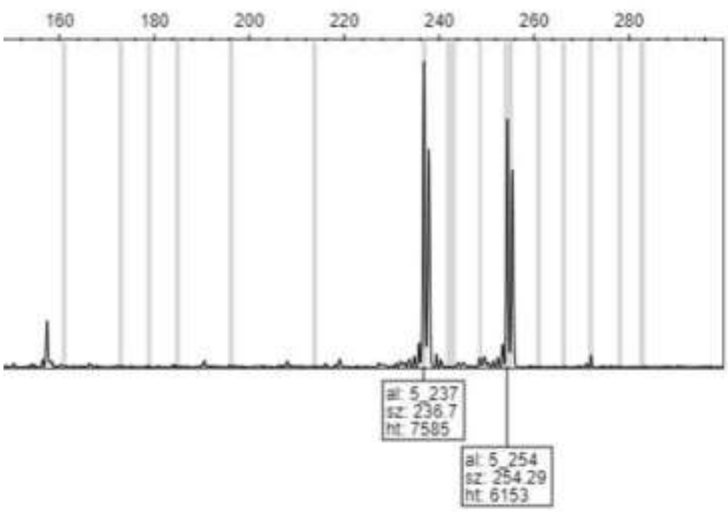

Figure 2. SSR fragment peaks obtained after capillary electrophoresis of cannabis SSR marker CS1 of sample 29.

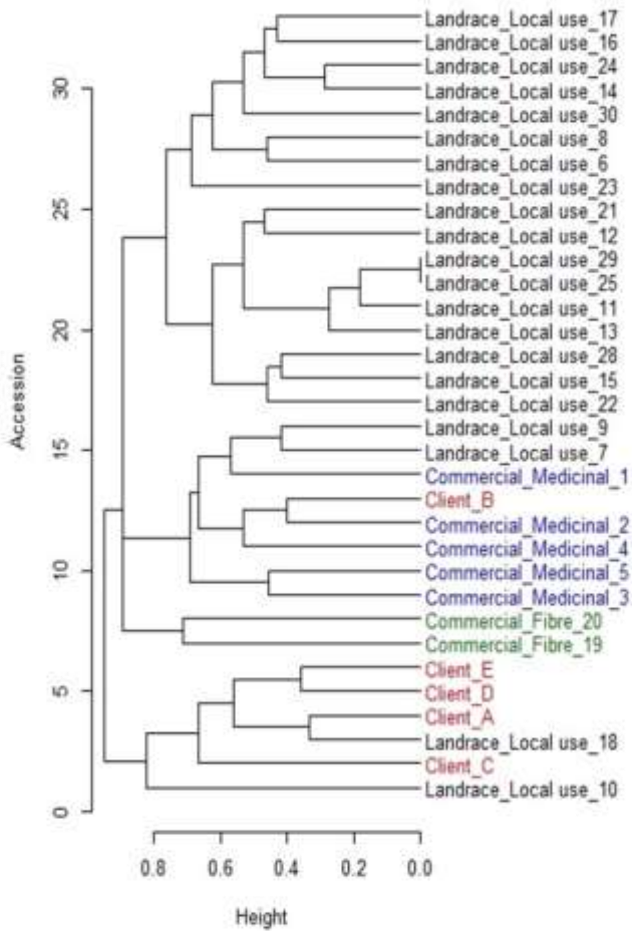

Figure 3. Complete cluster dendrogram of pairwise genetic distances calculated with the Jaccard distance measure of ARC and client cannabis samples genotyped with seven SSR markers.

Garden pests

Compiled by Diedrich Visser

Although our gardens are visited by hundreds of insect species, only a fraction may be regarded as pests. Some sources suggest that more than 97% of all insects in gardens are either beneficial or benign. In fact, we hardly notice them until our plants show damage symptoms. Most often the wrong insects are blamed as the "pests" in the garden, and many beneficial insects are killed in the process. Below are brief descriptions of a few insects that indeed sometimes reach damaging levels. However, most often even the most injurious pests only occur in such low numbers that even they may be ignored.

CMR Beetle

The CMR beetle (Fig. 1) is one of the largest insects in our gardens, and therefore easily noticed. They are primarily flower-feeders, but are often seen consuming other plant parts when flowers are not available. They are black with two bright yellow bands and two yellow spots on each forewing. If they occur in large numbers, and if they are inflicting serious damage, they can be removed by hand while wearing gloves (they exude a blistering fluid). They do, however, sometimes fly away when approached.

Leaf chafer beetles

These beetles are not often seen - they only emerge at night from their hiding places on the ground between fallen leaves. Although many different species occur in our gardens, it is mainly species in the *Adoretus* genus (small brown beetles approximately 10 - 15 mm in length, Fig. 2) that inflict continuous damage to the foliage of plants (the beetles return to the same plants every evening). Inexplicable irregular holes in leaves is a clear sign of the presence of these nocturnal beetles. If possible, visit the affected plants two hours after sunset, and remove the beetles by hand. The beetles mostly feed on the underside of leaves, and are very wary of their surroundings - slow movements and fast hands will be needed.

Pachnoda beetles

These are the very common yellow and black beetles in our gardens (Fig. 3). They feed on flowers and fruit. Their larvae are often found in compost heaps, characterized by their quick "walking" movements while on their backsides. The beetles often feed high up in trees, but if they are accessible, they can be removed by hand. Regularly turning of compost heaps while removing the larvae may help to reduce their numbers.

Caterpillars

Many different species of caterpillars occur in gardens. They are mostly the larvae of night flying moths, while a few are the immature stages of butterflies. Most caterpillars only occur in low numbers, and are only noticed when their numbers increase, or when plants are damaged. A few noteworthy caterpillars that sometimes become pests in gardens, include: African bollworm (Fig. 4), cutworms, semi-loopers, hawk moth larvae, and armyworms. Most caterpillars are under natural control by predators and parasitoids. These natural enemies play an important role in gardens, and are usually killed when pesticides are used indiscriminately. The best control option is to remove the caterpillars by hand, or to tolerate damage if possible - nature will take care of the rest.

Aphids

Aphids are very small sucking insects (Fig. 5) that usually occur in large numbers on plants. They may cause wilting of growth points when their numbers are high, but some may transmit viral diseases to healthy plants. If infested plants are sturdy, a strong stream of water may dislodge most of the aphids from plants. As with caterpillars, various natural enemies usually keep their numbers low. Some plants may tolerate huge numbers of aphids without showing any negative effects.

Stinkbugs and twig wilters

Many different species of sucking bugs may be found in our gardens. The two most common groups are the stinkbugs, and twig wilters. Most stinkbugs are shield-shaped, while most twig wilters are elongated with parallel-sided bodies (Fig. 6). Only a few species damage plants, by sucking on growth points or tender stems, causing wilting and dying off, of affected parts. These bugs can be removed by hand - they usually stay on the same plant for days at a time, and can also be located by looking for wilting growth points.

Other pests

Many other potential pests may be encountered in gardens. Most, however, only occur in low numbers and can be ignored. Other pests not mentioned above include: blister beetles, cabbage caterpillars, crickets, flea beetles, grasshoppers, leafminers, mealybugs, millipedes, mites, plant eating lady beetles, sawflies, snails and slugs, tortoise beetles, weevils, whiteflies, webworms, white grubs and wireworms. Most of these potential pests are under natural control, but some may cause damage to plants when conditions are favourable. Using insecticides against one of them may reduce the natural enemies of others, and that may cause secondary outbreaks of even the minor pests. The best option is to tolerate their presence, or to use alternative strategies, as described above.

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Figure 1. CMR beetle (25 mm).

Figure 2. *Adoretus* leaf chafer beetles (15 mm).

Figure 3. *Pachnoda* beetles (24 mm).

Figure 4. African bollworm (26 mm).

Figure 5. Maize aphids (3 mm).

Figure 6. Male twig wilter (29 mm).

Common viral diseases of Solanaceae species: A continuous battle to protect agricultural crops

Compiled by Julia Mulabisana and Michele Cloete

The family *Solanaceae* contains some of the most important crops, which plays a crucial role in the agricultural economy. These include food crops, flowers, ornamentals, medicinal crops and wild relatives of the common agricultural crops. The major solanaceous vegetable crops are potato (*Solanum tuberosum* L.), tomato (*Solanum lycopersicum* L.), eggplant (aubergine) (*Solanum melongena* L.), tobacco (*Nicotiana tabaccum*) and pepper (sweet pepper, chilli pepper, piquanté peppers-pepper dew, etc.) representing the highest percentage of horticultural production in the world. These are affected by a range of viral diseases. Jimson weed (*Datura stramonium*), climbing nightshade (*Solanum dulcamara*), Black nightshade (*Solanum nigrum*), etc., are among others, the wild relatives serving as sources of virus infection. Plant viruses are infective organisms that interferes with the normal functioning of the plants. The infection by viruses lowers yield and reduce the quality and production of most vegetable crops. Viruses are transmitted by aphids, whiteflies, or thrips, which are called vectors because they carry the virus from infected to uninfected plants while feeding.

Tomato spotted wilt virus **(TSWV)**

TSWV is widespread throughout the world. In South Africa, it was a problem in the tomato production areas of the Western Cape and the Eastern Cape and in some cases, in other parts of the country where host plants are grown. It is transmitted from infected plants to healthy plants by insect vectors called thrips. Different types of thrips have been reported, but the onion thrips, western flower thrips and the tobacco thrips are commonly associated with transmission of TSWV.

TSWV has the widest host range, and infects species across 35 plant families, including both monocotyledons and dicotyledons. Solanaceae crops such as pepper, tomato, potato and tobacco are susceptible to the virus. Weeds species (e.g. *Datura stramonium*) and the black and climbing nightshades serve as important reservoirs for TSWV. Symptoms on the leaves will consist of necrotic (brown) and chlorotic (yellow) rings or ring patterns (Fig. 1A, B and C). The leaves will sometimes turn bronze. Necrosis of the stem and leaves may occur. Plants may be stunted and malformed. Affected fruits may show symptoms of paler areas, some chlorotic or necrotic ring spots. Green fruits may have areas with faint concentric rings (Fig. 1D and E). Uneven ripening of the fruits can occur. Plants infected early in the season may not bear fruits. Infected potato tubers may develop necrotic lesions on the surface and internally (Fig. 1F). The expression of symptoms can vary, depending on the stage at which the

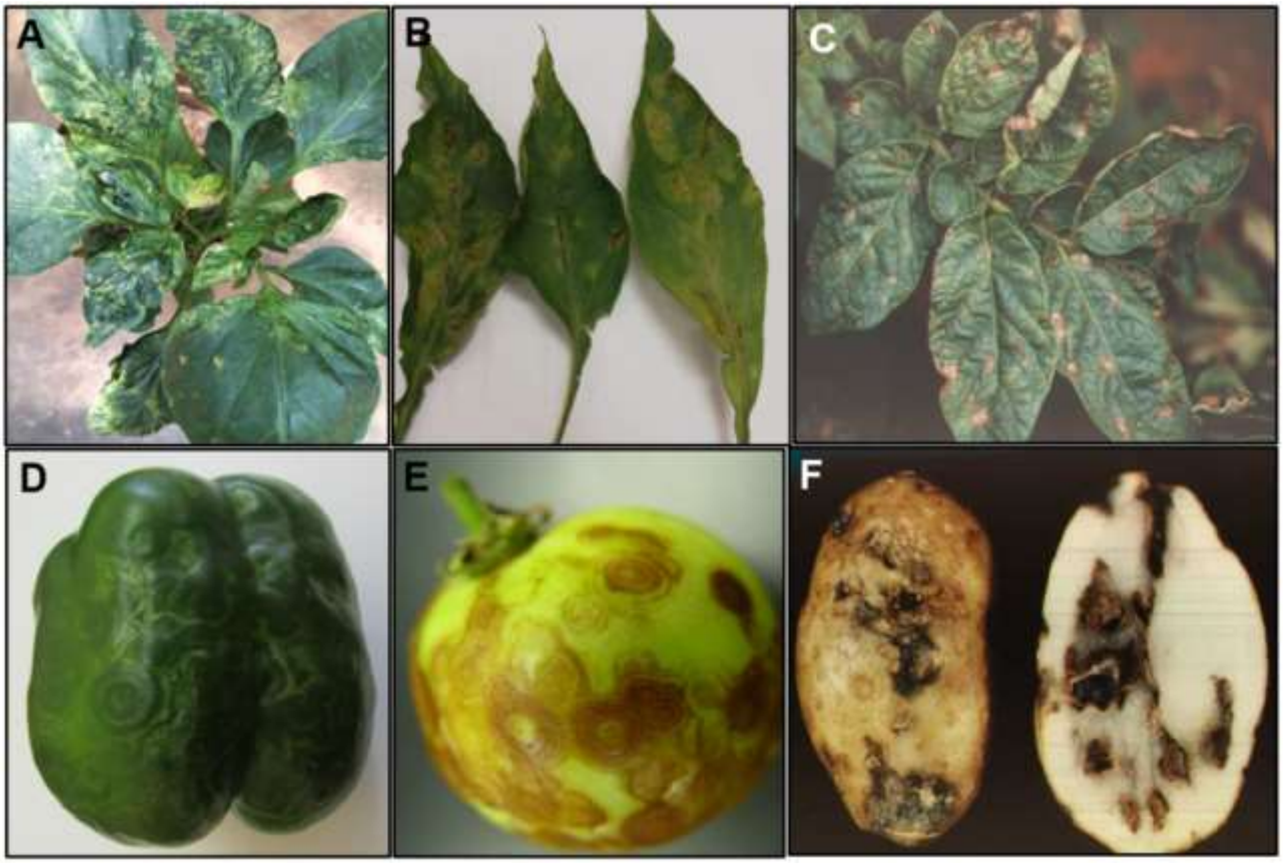

Figure 1. Symptoms associated with TSWV infection on the leaves and fruits of pepper, tomato and potatoes. A, B, and C: necrotic/chlorotic brown spots on the leaves of pepper and potato; D and E: necrotic rings on pepper and tomato fruits, and F: potato tubers with necrotic spots and internal rotting.

plants are infected.

***Potato virus Y* (PVY)**

PVY is a serious problem of potato, tomato, tobacco and pepper in many countries worldwide, including South Africa. The virus is a member of the potyvirus group. Yield loss on infected plants can occur. PVY is transmitted by insect vectors called aphids (green peach aphid, *Myzus persicae*). Initially, veins become yellow or transparent and later develop some mosaic patterns (Fig. 2A and B). In severe cases, leaves may have some dark brown dead areas on the mature leaves. Some yellowing along the veins can occur. Later, the foliage may curl downwards, giving the plant the drooping appearance.

Different strains of PVY have been reported (PVY^{O}, PVY^{N} and a recombinant called PVY^{NTN}) and these are prevalent in South Africa. PVY^{NTN} causes tuber necrotic ringspot disease on the surface of the tubers (Fig. 2C and D), and leaves will have symptoms that are characterized by veinal, leaf mosaics, crinkles, leaf drop and stunting of the plant.

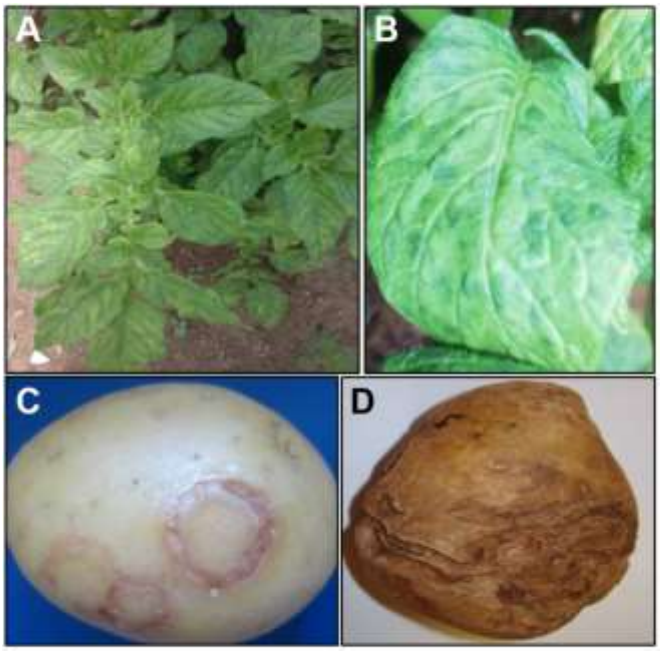

Figure 2. Symptoms induced by PVY on potato leaves and tubers. A and B: Mottling and yellowing of the leaves; C and D: necrotic ring spot disease due to the tuber necrotic strain of PVY. Photo (C) was taken from http://www.dpvweb.net/dpv/showfig.php?dpvno=414&figno=09 (Charlet-Ramage, K., INRA-GNIS, France).

***Cucumber mosaic virus* (CMV)**

CMV is distributed worldwide and it has a wide host range, attacking varieties of vegetables including peppers, tomato, cucurbits, tobacco, etc., and related weeds. It is transmitted by many aphid species including the green peach aphid (*Myzus persicae*). The aphid feeds on the infected plants and it could transmit it immediately (within minutes) to healthy plants. In pepper, CMV is reported to be transmitted through seeds. Transmission can occur through handling of the plants but there is very minimal chance of that happening because CMV is not as stable as TMV. The virus can also over winter in weeds (Chick weeds, nightshade, etc.).

Symptoms may vary, depending on the type of strain, the genetic makeup of the plant and the environmental condition. Plants may become stunted with light green leaves (Fig. 3A). Severe mosaic symptoms on the leaves can be seen (Figure 3B). Small necrotic (brown) ring spots can develop. Affected leaves may drop prematurely. Fruits may develop abnormally, sometimes with concentric rings, spots or blisters (Figure 3 C and D).

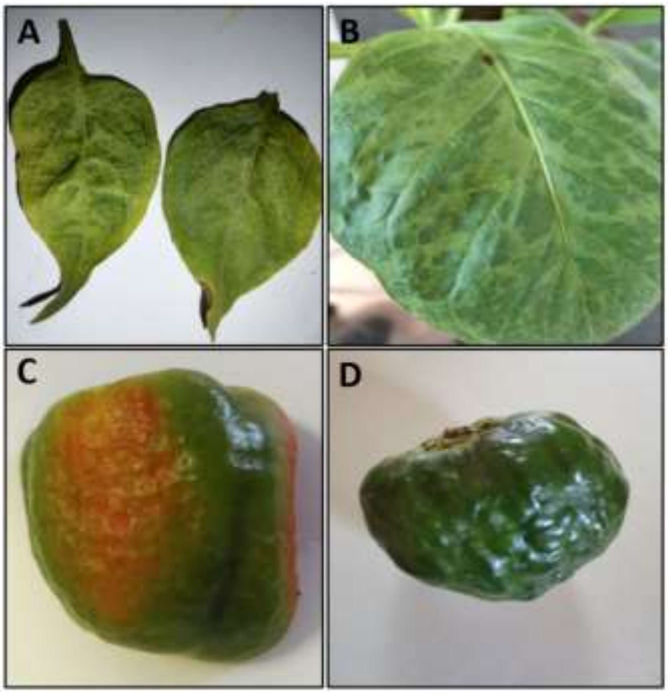

Figure 3. Symptoms of CMV on pepper (A) and tobacco leaves (B), with light green and yellow mosaic patterns on leaves; C and D: uneven ripening of pepper fruit with rings and a bumpy appearance on the fruit surface.

***Tobacco mosaic virus* (TMV) and *Tomato mosaic virus* (ToMV)**

TMV can spread quickly through seeds, infected tools, plant debris and when plants are handled frequently. *Tomato mosaic virus* (ToMV) can be regarded as another strain of TMV. This virus occurs at a higher concentration within the plant and is very stable, having the ability to survive for longer periods outside plant tissues (in tools, cigarettes, greenhouse frames, sawdust, etc.). This characteristic enables TMV to be readily spread by human activities (workers and implements). It can also survive in plant debris (up to two years) and infect plants through the roots. TMV and ToMV have a wide host range, including most members of the family Solanaceae, many ornamentals and weeds.

Symptoms include some mosaic (chlorotic) patterning on the leaves with light and dark green mosaic areas (Fig 4A and B) and leaf distortion (Fig. 4C). Older leaves can fall prematurely. Yield can be affected due to fewer fruit setting. Leaves are deformed and plants can be stunted. Shoe string appearance of the leaves may occur on young plants. Fruits, if affected, are characterized by some internal browning or brown wall appearance. Uneven ripening of the fruit can occur and the size and number of fruits produced can be reduced.

Figure 4: Symptoms associated with TMV on pepper and tobacco leaves. A and B: severe mosaic symptoms on tobacco leaves; C: distorted pepper leaves. Photo A was adapted from http://ushotstuff.com/TobaccoMosaicVirus.htm; B and C by L.P. Mphuthi.

Potato leaf roll virus **(PLRV)**

PLRV is a very important virus of potato in South Africa and worldwide. High yield losses due a single and co-infection of PLRV with potyvirus PVY have been reported. The virus spreads through infected seed tubers and volunteer potato plants from the previous planting seasons. Solanaceous weeds will carry the virus when the potato crop is not in season. The virus is also transmitted to healthy uninfected plants by the green peach aphid. Infected plants are stunted and have a light yellow to pale green colour (Fig. 5A and B). Leaves will roll upwards and rattle or make a cracking noise when shaken. Leaves may have purple discolouration on the edges of the leaves.

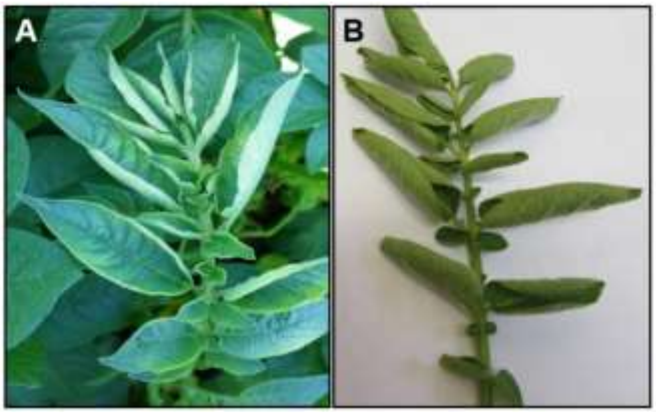

Figure 5. Symptoms induced by PLRV on potato leaves, showing the upward rolling of leaves.

Alfalfa mosaic virus **(AMV)**

This virus is common in alfalfa plants (*Medicago sativa* L.). In these plants, the transmission is reported to occur through seeds. The three lucerne aphids, the bluegreen aphid (*Acyrthosiphon kondoi*), pea aphid (A. *pisum*) and the spotted alfalfa aphid (*Therioaphis trifolii* f. maculata) are some of the aphids species known to transmit AMV. AMV has a wide host range, and it is known to infect potato, pepper and other solanaceous crops. Several woody species also serve as natural hosts. Symptoms are characterized by bright yellow leaves with a smooth surface (calico symptoms), and is often shiny (Fig. 6). AMV is also associated with external and internal tuber necrosis on potatoes.

Figure 6. Bright yellow leaves on potato plants due to infection by AMV. Photo by P. Steyn.

Tomato yellow leaf curl virus **(TYLCV) and** ***Tomato curly stunt virus*** **(ToCSV)**

TYLCV can be confused with several other tomato viruses and even some nutrient deficiencies. It is transmitted by whiteflies (*Bemisia tabaci*). The active adult whitefly acquires the virus while feeding. The virus persists in the insect, which can then be transmitted throughout its life. Plants infected with TYLCV are stunted, leaflets are rolled upwards, show interveinal chlorosis and are wrinkled (Fig. 7A). Affected fruits can be small in size. TYLCV has a wide host range and peppers can also be infected by this virus. ToCSV is also transmitted by the whitefly species *Bemisia tabaci*, which prefers tropical and subtropical conditions. Symptoms are similar to those induced by TYLCV, including foliar chlorosis, leaf curling, stunting and reduced fruit set. Leaves may appear purplish and later become necrotic with papery appearance (Fig. 7B). Many weeds are host to ToCSV, including most members of the nightshade family, such as *Datura* (thorn apple, stinkblaar).

Figure 7. Upward curling with pale green yellow edges due to TYLCV (A). ToCSV symptoms are characterized by curling of leaves and sometimes with purple pigmentation (B). Picture A from https://plantcaretoday.com/tomato-leaf-curl.html

OTHER VIRUSES

Viruses such as *Tobacco rattle virus* (TRV), *Tomato brown rugose fruit virus* (ToBRFV), *Tomato torrado virus* (ToTV), *Tomato chlorosis virus* (ToCV), *Pepper mild mottle virus* (PMMV), etc., are some of the viruses reported to infect solanaceous crops. ToCV, ToTV are some of the viruses found to infect some wild solanaceous species in South Africa, emphasising the importance of weed control.

VIRUS DETECTION AND CONTROL

Viral diseases are difficult to distinguish based on symptoms alone, and laboratory assays are needed to accurately identify viral pathogens in most cases. Unlike bacteria or fungi that can be treated with antibacterial or antifungal agents, viruses do not have chemicals that can effectively treat them. Management of plant viruses relies on preventing viruses from entering plants or disseminating from one plant to the other. Integrated disease management strategies listed below should be employed.

Disease free planting seeds/planting material

- Start with seed or seedlings that have been certified disease free and these are obtained from a reputable source.
- Planting new crops with certified virus-free potato seeds and planting material will also reduce the crop and yield losses.

Sanitation

- Scouting the production area for the occurrence of symptoms on the plants and insect vector (aphids) populations allow for the application of control measures in time. These will help to reduce the onset of infection. This is the most important practice in controlling viruses in general.
- Rouging/removing visible infected plants.
- Removal of volunteer plants (potato) which may have survived from the previous planting.
- Controlling weeds which enable the virus to survive (overwinter) in the absence of wanted agricultural crops.
- Minimal handling of plants should be practiced to reduce mechanical spreading of the virus.
- Wash hands with carbolic soap or sodium hypochlorite after working with plants.
- Disinfecting working equipment such as knives or clippers regularly after working with plants
- Planting solanaceous crops away from an alfalfa or wheat field will prevent infection by AMV.

Monitoring

- The use of sticky cards/traps (e.g. yellow and blue traps) will provide a way to detect the onset of thrips infestation and other insect vectors.

Chemical control

- When insect vectors (thrips/aphids/whiteflies) are known to be present, registered, effective chemicals should be used at recommended dosages to control them, in order to reduce the population build up and virus spread.

Resistant varieties

- The use of resistant varieties if available, can reduce infection and loss of crops due to plant viruses.

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A closer look at Potato early dying and *Colletotrichum* isolates from potato

Compiled by René Sutherland, Elsie Cruywagen and Mariette Truter

Potato early dying (PED) is a disease complex that results in premature senescence and ultimately the death of a potato plant. When early dying occurs, diseased and stressed plants result in reduced yields, with typically smaller tuber size and visible negative effects on tuber quality. Symptoms only become evident during crop maturity and advanced symptoms usually do not occur until after flowering. Symptoms of PED are often difficult to distinguish from normal senescence. Early foliar symptoms appear as chlorosis of lower leaves of plants. This is followed by stem lesions (Fig. 1) and wilting of plants. Symptoms progress up the stems and is followed by death of the plants. Results from a

Figure 1. Brown to black lesion observed on a potato stem from which *C. coccodes* was isolated. The lesion started to develop at the bottom of the stem and then spreads upwards as it develops.

recent ARC study showed that PED disease is caused by a complex of pathogens which only cause disease when plants are stressed. The fungal pathogen *Colletotrichum coccodes* is one of the major pathogens associated with PED disease. Over two potato production seasons in the Limpopo Province, 55 *Colletotrichum* isolates were isolated from diseased plants, and were identified as *C. coccodes* based on molecular markers. Pathogenicity tests in the greenhouse revealed that most of these isolates are virulent on the potato cultivar Mondial, and caused typical symptoms of black dot on the daughter tubers (Fig. 2). However, plants that were severely infected with *C. coccodes* showed symptoms similar to what were observed in the field (leaf chlorosis, stem lesions and wilting) after an extended period post-inoculation. It was concluded that these advanced above ground symptoms (leaf chlorosis, stem lesions and wilting) will be more rapidly observed in the field, when compared to the plants under glasshouse conditions. More rapid symptom development in the field is due to plants being exposed to other stress conditions, such as high temperatures and co-infection with other pathogens, such as *Verticillium dahliae* which is also part of the PED disease complex.

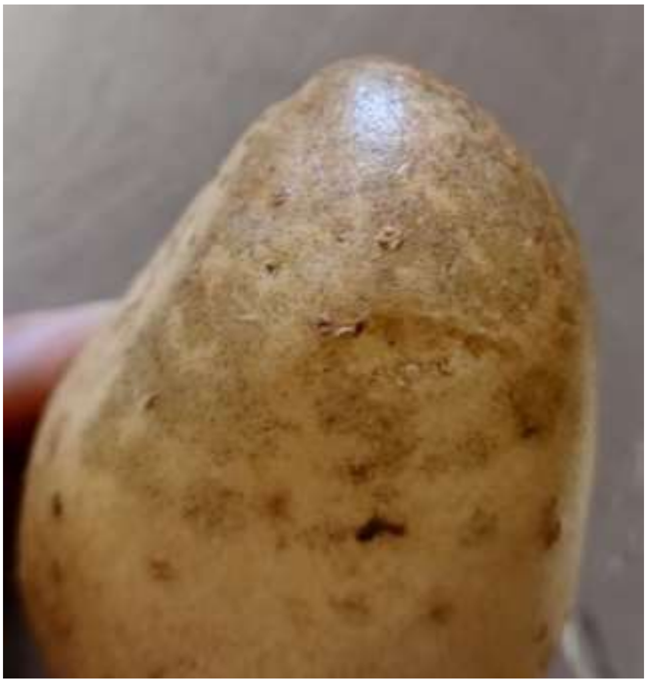

Figure 2. Potato tuber with typical black dot symptoms on the tuber skin, caused by *Colletotrichum coccodes.*

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Hydroponics in the context of water-energy-food nexus: a world's eye-catching matter

Compiled by Nadia Araya[1], Mduduzi Sithole[1], Adri Laas[1], Mariette Truter[1], Bridget Murovhi[2], Sonja Venter[1] and Ian du Plooy[1]

Hydroponics is a method of cultivating plants without any soil, using a mineral nutrient solution in a water-solvent growth medium. There are several techniques used worldwide, but in South Africa particularly, the vertical nutrient film technique (NFT, Fig. 1a), horizontal gravel film technique (GFT, Fig. 1b), bottle gardening (Fig. 1c) and bag systems (Fig. 1d) are amongst the most implemented ones. In systems such as the NFT, GFT and bottle gardening, the nutrient solution is continuously recirculated through plant roots, thus enabling increased water and nutrient use efficiencies. The NFT system allows vertical cultivation of plants, whereby planting pipes or trays are stacked on top of each other, with the nutrient solution channels interconnected to one another. The compacted setup of this system makes it more space efficient, which is particularly relevant in urban areas where the available land or space for plant production is often very limited.

Hydroponics offers great potential for increased resource use efficiency of the three essential elements (water, energy, and food) for human society. Water is needed by hydropower plants to generate electricity, which is the most utilized energy source for hydroponic systems in South Africa. Similarly, water is needed to produce food through fertigation. Energy, on one hand, is used for water treatment through reverse osmosis, while on the other hand is spent on food production through the operation of pumps, and cooling or heating systems in greenhouses. Food production, through crop growth manipulation, can reduce evaporation and drainage losses, leading to water savings in open/non-recovery hydroponic systems; while in recovery systems, crop water consumption is minimized because of continuous recirculation of water and nutrients through the system. Food waste can be used for biogas production using crop residues (stems, leaves, roots or damaged fruits) after harvest. Hydroponics also offer other added advantages associated with the circularity of the Water-Energy-Food (WEF) nexus. For example, there is high potential for the reuse of locally available materials, such as cold drink bottles, maize-meal bags and woodwork waste like sawdust for crop production.

As a result of the evident potential of hydroponics to tackle the problem of water, energy and food scarcity in South Africa, the Water Research Commission (WRC) in collaboration with the Agricultural Research Council (ARC) has initiated a project focusing on the development of optimum crop production management practices in hydroponics and their transfer to farmers through training and technology exchange. This project was selected by the WRC to serve as a demonstration of the WEF nexus to 35 international postgraduate students and researchers from across the globe (Fig. 2). The demonstration event took place on 10 August 2022 at the ARC-VIMP. An oral presentation on the WEF nexus in the context of hydroponics was made to the participants, including demonstrations of the operation and maintenance of hydroponic systems (Fig. 3).

Figure 1. Some of the most implemented hydroponic systems in South Africa, namely: (A) vertical nutrient film technique (NFT); (B) horizontal gravel film technique, (C) bottle gardening and (D) bag systems. Pictures taken by Nadia Araya at the Agricultural Research Council-Vegetable, Industrial and Medicinal Plants (ARC-VIMP).

Figure 2. Group photo of the international delegation that visited the demonstration at Roodeplaat, ARC-VIMP.

Figure 3. Post-graduate students and researchers being trained on vertical NFT production systems.

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National Science Week held during 1 to 5 August 2022

Compiled by Musa Mtileni and Buhlebelive Mndzebele

Teachers from Piet Retief discussing sweet potato and its contribution to fight food and nutrition insecurity in various schools.

The hydroponics production system being demonstrated to leaners from Ntokozo Combined school in Mayflower. They are interested in starting a vegetable garden, and have, subsequently, made a follow-up after the National Science Week on when can they start establishing their garden.

The National Science Week is an initiative by the Department of Science and Innovation (DSI) to create a society that is knowledgeable about science, critically engaged and scientifically literate. The aims of the week were:

- To popularise science to the broader South African society.
- To serve as a vehicle for showcasing local innovations in science and technology. and the leadership role of the DSI and other government departments in enabling research, development and innovation.
- To make science, technology, engineering, mathematics, and innovation (STEMI) appealing to learners, such that they consider STEMI as preferable career options.
- To familiarise targeted participants with the science linked to areas in which South Africa has knowledge and/or a geographic advantage so as to contribute in making them informed and critically engaged citizens.

The Agricultural Research Council (ARC) participated in the Nation Science Week held during 1 to 5 August 2022 at the Mondi Centre. During the week, 87 schools visited the indoor exhibitions at the centre, including 8902 learners and 390 educators.

A presentation was presented on the business of the ARC, which is conducting research, develop partnerships and human capital, and to foster innovation for a sustainable agriculture sector through several campuses country wide. In addition, the work being done by the ARC-VIMP was demonstrated, with the emphasis on hydroponics production. Several products produced by the ARC were also show cased. Opportunities were shared with the learners, teachers and the communities for them to optimally benefit from. These entailed experiential learning, internships, the ARC's Professional Development Program (PDP), and employment opportunities. At the end of each presentation learners were encouraged to consider agriculture as a career. It was noted with disappointment that most of the learners were from resource constrained communities in which there is limited land, as well as a lack of agricultural knowledge. These are key drivers that are worsening the growing poverty levels in the country, which is estimated to be about 54%. This rate is higher in the rural communities constituting most of the visitors to the centre. To address such challenges, the ARC showcased training opportunities in various aspects to enhance food and nutritional security.

The visit to the ARC exhibition site showed interest in the hydroponics systems which enables farmers to grow vegetables without the utilisation of soils. These entailed the bag system, as well the gravel flow technique. It was disappointing that there were only a few schools which were teaching agriculture as a subject, with some of these schools showing an interest in vegetable production. However, they did not have the knowledge and they requested the ARC to help them establish vegetable gardens. This created opportunities for the ARC to offer training in several agricultural aspects for the learners to be able to utilise the land efficiently and to produce quality produce. Sweet potato, spinach, butternut and carrot were indicated as key crops to be established in vegetable gardens in the interested schools. The impact made by the ARC was followed by a candid appreciation for the success of the National Science Week 2022 event. The contribution made by the ARC was of the highest quality, demonstrated through passion, coupled with commitment and excellence. The ARC received a letter of gratitude from Mondi Science for its contribution made during the National Science Week. An invitation has already been put forward to request the ARC to participate in the 2023 National Science Week to be held in Piet Retief.