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Inside this issue:

Dr Sunette Laurie, a sweet potato plant breeder of note

Dr Sunette Laurie, Specialist Researcher from the Plant Breeding Division, was chosen as one of Africa's 20 most influential plant breeders of 2020 by the Southern African Plant Breeders Association. She has worked as a sweet potato breeder since 1994 and has released 20 sweet potato varieties so far, including nine cream-fleshed and 11 orange-fleshed varieties. Currently, the most widely promoted of these are cultivars 'Ndou' and 'Monate', being the most widely adopted of the cream-fleshed, dry texture and sweet cultivars grown for the informal market. Orange-fleshed sweet potato cultivars 'Bophelo' and 'Impilo' are disseminated on a wide scale for addressing vitamin A deficiency.

Much of her effort goes into the provision of high quality, virus-indexed planting material on an annual basis to sweet potato vine growers. This keeps production profitable by limiting infection by sweet potato viruses, insects and wilt disease. Great progress was made in establishing nurseries with improved ARC sweet potato cultivars at small-scale commercial vine growers, which provide producers with healthy planting stock. She also has a passion for community development and is involved in a crop-based approach program providing training in cultivation to curb malnutrition.

Current research involves breeding of sweet potato varieties with tolerance to wilt disease (*Fusarium oxysporum* f. sp. *batatas*). Collaborative research includes the screening of ARC sweet potato lines for their host status to tropical nematodes, development of composite flour and its use in processing, determination of the phytonutrient content of sweet potato leaves, and analysis of the effects of drying methods on sweet potato drying kinetics and quality. Students, which recently completed their studies under Dr Laurie's supervision, performed research on enhancing the nutritional quality of sweet potato, including protein content, the effect of drying using an indirect semi-solar dryer on the phyto-nutritional components of sweet potato flour and on the optimization of sweet potato cultivation which included the evaluation of biological control agents for the management of the sweet potato weevil.

Dr Laurie has made a notable contribution to the body of research data available on sweet potato, both internationally and nationally. She has published 69 papers in peer-reviewed journals/proceedings (with 28 as the main author), seven technical reports, three books, nine chapters in books, and was the editor of one book. She also presented 196 presentations at international and national conferences. Her NRF rating was upgraded to C2 (established researcher with some international recognition) in January 2020.

The International Society of Horticultural Science (ISHS) awarded her with the ISHS medal for convening the Second International Symposium of Moringa in November 2019. The proceedings of this symposium was published in April 2021 in *Acta Horticulturae* 1306.

Unique sweet potato varieties for the local industry

Compiled by Sunette Laurie[1], Whelma Mphela[1], Andre van den Berg[1] and Musa Mtileni[2]

Sweet potato is the second largest root crop produced in South Africa after carrots. The gross value of sweet potato production in South Africa is estimated at R270 million per year. Large quantities of fresh produce are sold in supermarkets, while the crop is popular amongst small-scale farmers because of its resilience and contribution to food security. The ARC-VIMP is a leader in sweet potato research and development in South Africa. The sweet potato breeding programme aims to import, maintain, develop and evaluate breeding lines towards addressing food security and malnutrition, and for income generation.

Twenty sweet potato elite lines, with the flesh colour varying from cream to orange, are currently being evaluated at various agro-ecology sites and under various production conditions. The new lines offer a medium dry texture, uniform round elliptical to short obovate shaped tubers, as well as an attractive appearance (Table 1 and Fig. 1). The cream-fleshed line FS1-1 produced a high percentage marketable yield of 84%. The total and marketable yield of the orange-fleshed lines are similar to the yield of Beauregard (commercial cultivar), while the taste of the cooked products are more acceptable. These lines offer high total carotenoid content varying from 119.27 to 146.28 µg/g.

Semi-commercial evaluation was completed at Brits and Malelane, and the trial harvested at Clanwilliam during May 2021. Taste benchmarking shows that the market demand for fresh sweet potatoes is slowly changing to incorporate various types, specifically sweet tasting, dry-textured types developed by the ARC, rather than moist, soft types. Agronomic evaluation trials were conducted at three experimental stations namely Tompi Seleka, Tovoomba and the University of Venda and an on-farm demonstration trial was established in Bokfontein. Some promising lines including 2014-13-1, 2014-7-3 and 2015-1-6 (orange-fleshed), and 2014-14-5 (cream-fleshed) were selected for the application of plant breeder's rights (Fig. 1). These evaluations were expanded this year to Tsholomnqa – East London (Eastern Cape), eMcitsheni – Ladysmith (KwaZulu-Natal), Sena – Makhado (Limpopo) and Jericho – Brits (North West) (Fig. 2).

During February to May 2021, healthy mother stock of popular cultivars were disseminated to small-scale commercial nurseries near Rustenburg, Makhado and Tzaneen. This assists the vine growers (members of the Sweet Potato Vine Growers Association) to renew their vine multiplication blocks. This process is critical to reduce virus and disease build-up in planting stock and to increase the availability of improved ARC varieties to small-scale farmers. The ARC through the sweet potato disease-indexed scheme annually provides 15-20 commercial producers and vine growers with planting stocks. During 2020, 18349 plantlets in seedling trays and 2200 4-node cuttings were disseminated, including to two international clients. Hence, the sweet potato industry remains profitable since the destructive effects of viruses on sweet potato yields are curbed.

Table 1. Major traits of selected promising sweet potato elite lines as evaluated at Roodeplaat during the 2020-21 season

Cultivar/Line	Colour Skin	Colour Flesh	Shape	Leaf spot %	Total Carotenoids (µg/g)	Oxidation rating*	%Dry matter
Blesbok	Purple	Pale cream	Long oblong	18		3,9	17,3
FS 1-1	Cream to cream pink	Pale cream	Round elliptic	10		4,1	19,5
2014-14-5	Pale cream, pink tips	Pale cream	Short obovate	5		3,6	24,8
2014-7-3	Orange pale red	Dark orange	Short obovate	5	119,27	4,0	20.9
2014-13-1	Orange	Dark orange	Elliptic	8	126,33	2,1	20,9
Beauregard	Bright purple pink	Orange	Oblong	8	56,32	4,3	18,0
2015-1-6	Orange	Dark orange	Round elliptic	8	146,28	3,8	22,4

Cultivar/Line	Marketable yield		% per size class			Total yield	Cooked taste
	t/ha	%	L	M	S	t/ha	%Yes
Blesbok	54,8	76	29	34	15	65,3	25%
FS 1-1	46,1	84	19	50	27	53,6	33%
2014-14-5	38,7	76	17	51	29	46,3	68%
2014-7-3	34,5	70	8	38	54	41,3	69%
2014-13-1	36,5	75	13	47	41	44,0	38%
Beauregard	34,3	75	22	51	19	40,1	8%
2015-1-6	32,0	78	19	51	28	40,1	62%

*Oxidation rating scale: 1=very poor to 5=very good

Figure 1. Promising new ARC sweet potato lines evaluated during the 2020-2021 season. In the process of release are lines 2014-14-5 (ARC-SP-9), 2014-13-1 (ARC-SP-6), 2014-7-3 (ARC-SP-7) and 2015-1-6 (ARC-SP-8). The latter two lines are both producing a high percentage of marketable roots per plant and an uniform root shape.

Figure 2. Trial establishment at Zikana project, Tsholomnqa – Ngqinisa Village (Buffalo City Municipality, East London) on 12 March 2021 (left) and Sena, Dzanani (Makhado area, Limpopo) just before harvesting on 30 March 2021 (right) where 20 and 24 elite lines and control cultivars were tested, respectively.

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Sweet potato hawk moth, a potential serious pest

Compiled by Dr Diedrich Visser, Crop Protection Division, ARC-VIMP

Approximately 41 insect pests are known to attack sweet potato (*Ipomoea batatas*) in South Africa. One of the key pests is the sweet potato hawk moth (*Agrius convolvuli*). These moths are characteristically streamlined with narrow wings and pointed abdomens. This, and the fact that they fly strongly, usually at night, give them their common name of hawk moths. The larvae of the sweet potato hawk moth only attack sweet potato, morning glory and other members of the sweet potato family. It occurs throughout Africa and on neighbouring islands, as well as in Europe, Asia and Australia. In European countries, this hawk moth is known as a migrant because it quickly reinvades areas that are too cold for it to survive in during winter. In South Africa, however, winters are relatively mild and the migratory habits of the moth are therefore irrelevant, other than making it possible for it to infest distant, previously uninfested plantings.

The sweet potato hawk moth is a pollinator of certain night-flowering plants. These include plants with tubular flowers, such as *Nicotiana*, *Petunia*, *Lilium*, *Phlox* and *Jasminum*. The moths are only active at night, from dusk to midnight, and are strong fliers; they visit flowers even in adverse weather conditions.

Description

Moths are 40 - 45 mm in length, with a wing span of approximately 100 mm. The forewings are grey with darker patches and markings, while the hind wings have wavy, blackish lines on a grey background. The abdomen has characteristic pink and black segmented lines with a dorsal longitudinal grey line running to the tip of the abdomen. Two distinct red spots are present on the upper abdomen, just behind the areas where the wings attach.

Female moths lay eggs singly on foliage of sweet potato plants. The young and small larvae are pale green, but older ones vary considerably in colour and body pattern. Seven oblique lines are usually found on the sides of the abdomen. Older larvae may be green, yellow, which is rare, or brown to blackish, sometimes with a white lateral band running between the legs and the spiracles. Pattern variations may be extensive; other lateral and dorsal lines may also be present on the body. In most individuals the spiracles are pronounced because each may be encircled by a red or black ring.

A characteristic of all instars is a slender, sharp tail, which is more pronounced (longer) in younger individuals. Larvae pass through five instars and grow to a length of approximately 100 mm. Pupation takes place in the soil beneath plants, but when the soil is waterlogged or too hard, the mature larvae may walk considerable distances to find suitable pupation sites. Pupae are formed at depths of 10 - 20 cm in the soil. They are mahogany-coloured with a distinct 'jug-handle'- or 'elephant trunk'-like proboscis (*see photograph*). Depending on the ambient temperature, the life cycle may be completed in 1 - 2 months. Up to four generations per year have been reported.

The sweet potato hawk moth is a large, grayish moth with black and purple markings on the abdomen.

Older caterpillars hide under the leaves they are feeding on.

Damage

Only the larvae are responsible for damage to sweet potato; young caterpillars nibble holes through leaves while feeding during the day or night. Older larvae may consume entire leaves. Because they position themselves on a stem under a leaf while feeding, the larvae are usually not spotted in fields. Sometimes the first signs of an infestation are open or bare patches in a field where leaves have been completely removed during feeding. Fully-grown larvae usually do not feed during the day, but hide against a lower stem or on the ground.

Control

Control is only needed when high numbers of larvae are present in fields and when they are causing damage to foliage. Insecticides are registered to control insects on sweet

Older caterpillars are voracious feeders and may consume large amounts of foliage at night.

Pupae have a characteristic proboscis resembling a 'jug-handle' or 'elephant trunk'.

potato in South Africa, including the sweet potato hawk moth. Collection of larger larvae by hand when planting in small plots is an option. Ploughing or reworking the soil may expose and kill pupae. Removing weeds that belong to the sweet potato family (Convolvulaceae), e.g. bindweed, may reduce infestation of nearby sweet potato fields. Several parasitoids are known to be effective natural enemies of the caterpillars of the sweet potato hawk moth.

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Viral diseases of sweet potato – Reason for concern?

Compiled by Julia Mulabisana[1] and Sunette Laurie[2]

Sweet potato (*Ipomoea batatas* L. Lam.) is grown on a small scale as an important and reliable source of food for the resource poor, and it contributes significantly to food security and income generation for smallholder and commercial farmers. Like several other crops, sweet potato is prone to virus infections which have been associated with substantial yield and quality losses. More than 30 viruses occur naturally worldwide on sweet potato and more than one virus species can be found infecting a single sweet potato plant. Research at the Agricultural Research Council showed that mixed infections of begomovirses such as Sweet potato leaf curl virus and the potyvirus Sweet potato feathery mottle virus cause yield losses of up to 68% on average, in the first season of planting. Healthy planting material can yield 20 to 25 t/ha while infected material can only yield 1 to 4 t/ha when infected with multiple virus species.

Virus infected sweet potato plants (infected vines) used as planting material act as sources of infection. Viruses of sweet potato are mostly restricted to members of the genus *Ipomoea,* which includes the morning glory and sweet potato. The common morning glory *Ipomoea senensis* (Ders.) Choisy is a host of many sweet potato viruses. The total and marketable yield in sweet potato production is affected negatively by viruses, nematodes, fungi, bacteria and some physiological factors that occur underground during storage root development, and some of these will be described later on.

COMMON SWEET POTATO VIRUSES IN SOUTH AFRICA

Sweet potato feathery mottle virus and Sweet potato virus C

These are viruses that are transmitted by aphids (*Myzus persicae* and *Aphis gossypii*). Aphids acquire the virus from the infected plants in less than one minute while feeding, and subsequently, transmit it to healthy plants in only a few seconds. Leaf symptoms (Fig. 1) vary with variety, climatic conditions and plant age. Sweet potato virus C was previously named the C strain of Sweet potato feathery mottle virus, however, comparison of the coat protein amino acid sequences revealed that it is distinct from other strains of Sweet potato feathery mottle virus.

Plants may not show symptoms. When present, leaf symptoms may include diffuse mottling, with faint to distinct chlorotic spots, which may or may not have purple pigmented borders, irregular chlorotic patterns (feathering) along the main veins, vein yellowing and mosaic patterning (Fig. 1A, B, C, D and E), especially when more than one virus is involved. Symptoms are usually found on older leaves. Symptoms are seldom seen on the leaves in the field and is dependent on the growth stage, variety and the degree of stress, but the yield can decrease severely and there can be an increase in the number of cracked storage roots.

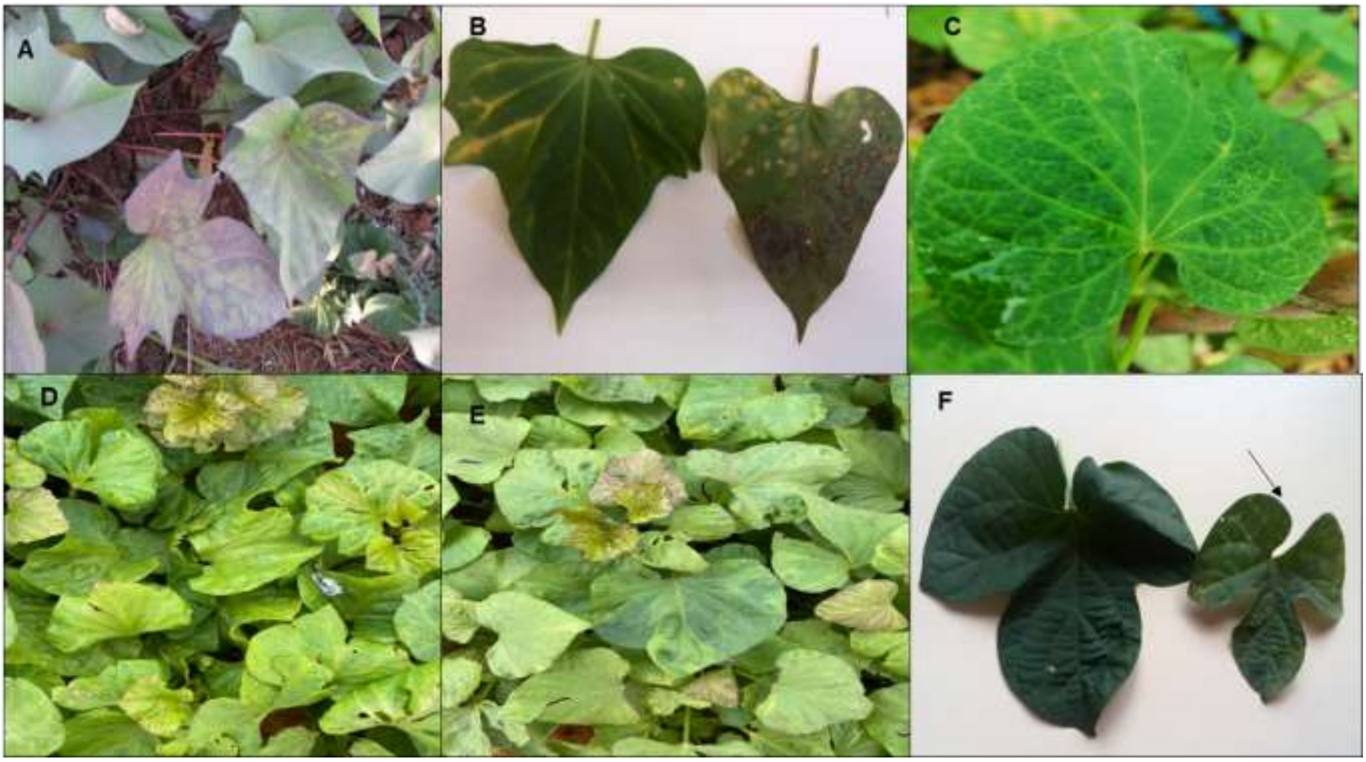

Figure 1. Virus symptoms associated with Sweet potato feathery mottle virus and Sweet potato virus C. A and B: Chlorotic spotting with purple pigmentation and vein yellowing; C: Feathering and vein yellowing along the main veins; D and E: Yellowing along the main veins and irregular chlorotic patterns (green and yellow) and F: *Ipomoea* sp. exhibiting some vein yellowing symptoms (indicated with an arrow).

Sweet potato virus 2 and Sweet potato virus G
Other viruses of sweet potato include Sweet potato virus 2 (also referred to as Sweet potato virus Y) and Sweet potato virus G, which are also a concern to sweet potato producers in South Africa. Although single infections do occur occasionally, these viruses are mostly detected in samples that are already infected with Sweet potato feathery mottle virus or Sweet potato virus C. These two viruses are transmitted by aphids (*Myzus persicae* and *Aphis gossypii*).

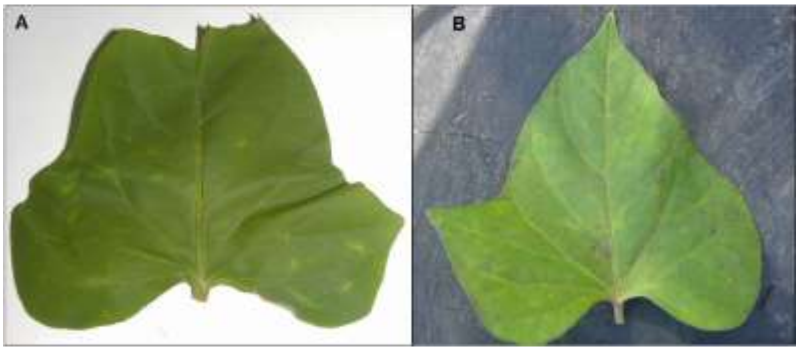

Figure 2. Virus symptoms associated with Sweet potato virus 2 and Sweet potato virus G. A: Chlorotic spots and B: Feint purple ring spots.

Symptoms induced by infection with a combination of Sweet potato feathery mottle virus and Sweet potato virus 2 and/or Sweet potato virus G are more severe than when it occurs as a single infection, and symptoms can be similar to those exhibited by infection with Sweet potato feathery mottle virus/ Sweet potato virus C. As a single infection, Sweet potato virus 2 does not always induce symptoms, however, symptoms such as mild chlorotic/yellow spots can occur and sometimes diffuse mottling is present (Fig. 2A). Symptoms of Sweet potato virus G include mild mottling, vein yellowing or purple ring spots (Fig. 2B). The size and number of storage roots can also be affected.

Sweet potato leaf curl virus
Sweet potato leaf curl virus is a begomovirus transmitted by whitefly species (*Bemisia tabaci*). Sweet potato leaf curl Sao Paulo virus, Sweet potato leaf curl and Sweet potato mosaic virus are begomoviruses that have been reported to occur in South Africa. The three viruses can be found infecting a single sweet potato plant and this has been

Figure 3. Symptoms associated with infection by the Sweet potato leaf curl virus. A and B: Upward curling or rolling of sweet potato leaves.

confirmed to occur in the Limpopo, Mpumalanga and Gauteng Provinces. Symptoms of infection with Sweet potato leaf curl virus are characterized by the upward curling or rolling of leaves on susceptible varieties (Fig. 3A and B). In severe cases, plants are stunted. Drastic yield losses have been reported with infection of begomoviruses as a single infection or in a co-infection with Sweet potato feathery mottle virus or Sweet potato virus C.

Sweet potato chlorotic stunt virus

Sweet potato chlorotic stunt virus is a crinivirus that is transmitted by the whitefly (*Bemisia tabaci*). It is the most serious disease of sweet potato in East and West Africa and has also been reported in isolated areas in Southern Africa. Single infections with Sweet potato chlorotic stunt virus induce mild symptoms, which are often confused with nutritional deficiencies. When found in association with Sweet potato feathery mottle virus, it causes Sweet potato virus disease (SPVD), which is a serious disease characterized by stunting (Fig. 4A), vein yellowing and purple pigmentation (Fig 4B), leaf narrowing and mosaic pattering (Fig. 4C and D).

Figure 4. Symptoms of co-infection with the Sweet potato chlorotic stunt virus and the Sweet potato feathery mottle virus. Symptoms are characterized by stunting of the plant with vein yellowing (A), vein yellowing with purple pigmentation (B), leaf narrowing and mosaic patterning (C and D).

Control and preventative measures of infection by sweet potato viruses

The re-use of sweet potato planting material is strongly discouraged. Farmers should obtain cuttings from vine growers who annually replace their stock with virus-indexed planting material obtained from the ARC-VIMP. Other control measures include the following:

- Isolation of the new season crop from old sweet potato field plantings, preferable by a distance of >500m.
- It is essential to control weeds in and around the field, especially the wild *Ipomoea* species, since these harbour viruses when sweet potato is not in season.
- Removal of volunteer sweet potato plants, which may have survived from previous plantings, is essential.
- Chemical control of aphids has little effect due to the rapid nature of transmission, however, preventative spraying can limit the spread of viruses.

The ARC-VIMP over many years has kept the sweet potato industry profitable by running a disease-tested scheme. The scheme provides healthy mother stock plants, which enables vine growers to start each season with planting material of disease-tested origin. To prevent planting and multiplication of virus-infected plants, it is advisable to submit samples to the ARC-VIMP Diagnostic Center where samples can be analyzed for the presence of common sweet potato viruses affecting production in South Africa. For more information on sweet potato viruses and how to obtain sweet potato cultivars as planting material, you are welcome to contact Dr Julia Mulabisana (mjmulabisana@arc.agric.za) and Dr Sunette Laurie (slaurie@arc.agric.za) or via 012 427 9700.

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Sweet potato tuber cracking – more to it than meets the eye

Compiled by Julia Mulabisana[1], Sunette Laurie[2] and Mariette Marais[3]

Various cracks are commonly observed on harvested sweet potato storage roots and these affect the marketability of the harvest. The appearance of cracks depend on several factors and some varieties may be genetically prone to cracking. With virus infection, cracks can also increase, however, Clark and Moyer (2013) indicated that sweet potato viruses are secondary factors that can be associated with cracking. Russet cracking (Fig. 1A) is one of the conditions associated with Sweet potato feathery mottle virus infection. However, factors such as uneven growing conditions and fluctuations in soil moisture have been strongly associated with cracking of the storage roots (Clark and Moyer, 2013).

Plant-parasitic nematodes are also a constraint to production of many crops, including sweet potato. These are common in sandy soils, however, infestation by different species have been reported in clay soils. *Meloidogyne* species (i.e. *M. incognita*) are the most damaging group of plant-parasitic nematodes and these have been reported in more than 50% of the sweet potato production areas in South Africa (Marais *et al*., 2017). Plant-parasitic nematodes have been associated with cracks on the storage roots of sweet potato, making the storage roots unmarketable (Lawrence, 1986, Clark and Moyer, 2013). *Rotylenchulus parvus* is another species of plant-parasitic nematode responsible for cracking in susceptible sweet potato cultivars.

Crops affected by plant-parasitic nematodes may show some stunting, yellowing of the leaves, and some may senescence at an early stage of growth. Affected sweet potato storage roots are characterized by deep cracks that exhibit severe distortion (Fig. 1B, C, D and E). With heavy infestations, marketable storage root yields will be highly affected. Plant-parasitic nematodes affecting sweet potato have been recorded in the Limpopo, North West, Western Cape, Eastern Cape, Mpumalanga, KwaZulu-Natal and Northern Cape Provinces.

More than 30 species of plant-parasitic nematodes affect sweet potato production, however, *Criconema mutabile*, *Meloidogyne incognita*, *Nanidorus minor*, Paratrichodorus sp., *Rotylenchulus parvus*, *Meloidogyne javanica*, *Criconemoides sphaerocephalus*, *Helicotylenchus dihystera*, *Meloidogyne* sp., *Pratylenchus zeae*, and *Scutellonema*

Figure 1. Different types of cracks observed on sweet potato storage roots during harvesting. A: Russet cracks associated with Sweet potato feathery mottle virus, B and C: Deep side cracks associated with infection by *Meloidogyne* spp., Tiny holes indicated with a black arrow around the crack is an indication of the presence of plant-parasitic nematodes. D and E: Severe cracking associated with infection by *Rotylenchulus parvus.* F: Healthy sweet potato storage root.

brachyurus are the most prevalent according to the South African Plant-Parasitic Nematode Survey (SAPPNS) (Marais et al., 2017).

An integrated management strategy is recommended for the control of plant-parasitic nematodes in sweet potato production. Crop rotation, the use of nematode-free planting material and the use of nematicides are recommended, however, nematicides should be used with caution since they may pose as a risk to human health and the environment. Nematicides can increase the inputs costs for smallholder farmers who cannot afford chemical treatments. The use of resistant sweet potato varieties is recommended as the most economical, effective, and environmentally safe method of managing plant-parasitic nematodes.

Sweet potato cultivars Bosbok and Mvuvhelo were found to be non-hosts to tropical plant-parasitic nematodes, while Blesbok is not affected by nematode infection but allows reproduction (Pofu et al., 2016, 2020). Screening for the host-status to tropical plant-parasitic nematodes is now included in the ARC-VIMP sweet potato breeding programme, in collaboration with the Green Technologies Research Centre at the University of Limpopo, to identify sweet potato cultivars with resistance to plant-parasitic nematodes, which will be high yielding, and that will produce good quality marketable sweet potato tubers.

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For more information on sweet potato viruses and how to obtain sweet potato cultivars as planting material, you are welcome to contact Dr Julia Mulabisana (mjmulabisana@arc.agric.za) and Dr Sunette Laurie (slaurie@arc.agric.za) or via 012 427 9700. For more information on plant-parasitic nematodes of sweet potato, please contact Dr Mariette Marais (MaraisM@arc.agric.za). The Guide to sweet potato production in South Africa can also be purchased from ARC-VIMP by contacting Switch Board at 012 808 8000.

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A step closer to harness bacteria for sweet potato health

Compiled by Sherly Mabena[1,2], Mariette Truter[1], Sunette Laurie[3], Quenton Kritzinger[2] and René Sutherland[1]

Plant growth promoting rhizobacteria (PGPRs) are symbiotic, free-living bacteria that have beneficial effects on plants. PGPRs can enhance and promote plant growth, productivity and the nutrient status of plants, protect them against invading pathogens and enhance their tolerance against abiotic stresses. As chemicals have a negative impact on the environment, PGPRs can be applied as biofertilizers or as bio-control agents. To identify bacteria with PGPR traits, 300 bacterial isolates, previously isolated from the rhizosphere of sweet potato, were further characterized.

Phosphate solubilisation

Phosphate is generally abundant in agricultural soils but the majority is present in an insoluble, immobilized and precipitated form. The limited availability of phosphate in the soil can often limit plant growth. Phosphatic fertilizers are usually applied to overcome this deficiency but they are costly and are immobilized soon after application. Therefore, if PGPRs can convert insoluble organic and inorganic phosphate to a form that is more readily accessible to plants, there will be an increase in phosphate uptake by the plants (Fig. 1).

Sequestering iron

Iron-like phosphate is abundant in the soil, however, it normally occurs as ferric ions and forms insoluble hydroxides

Figure 1. Evaluation of phosphate solubilisation activity. Different bacterial isolates were spot inoculated onto Pikovskaya (PVK) agar plates. The halo zone around the bacteria (top of plate) indicates phosphate solubilisation activity.

Figure 2. Evaluation of siderophore production activity. Bacterial isolates were spot inoculated onto chrome-azurol S (CAS) agar. Colourless halos around bacteria indicate siderophore excretion.

thus making it unavailable for uptake by plants. PGPRs synthesizes low-molecular weight siderophores that bind to ferric ions that can be taken up by the host plant (Fig. 2).

Inhibition of fungal pathogens

Competition between plant pathogens and PGPRs can limit disease incidence and severity in host plants. PGPRs can successfully colonize the rhizosphere, use up most of the available nutrients leaving little or no nutrients for pathogens and by doing so, outcompete the pathogens. PGPRs colonize the rhizosphere through the production of siderophores, antibiotics, biocidal volatiles, lytic enzymes, and detoxification enzymes (Fig. 3).

Figure 3. Inhibition of a soil-borne pathogen (*Fusarium oxysporum* f.sp. *batatas*, causal agent of Fusarium wilt) by PGPRs. Bacterial isolates were streaked in the centre of the plate, with the pathogen placed on both sides of the plate (2.5 cm away from bacteria). Left: Signs of fungal inhibition. Right: no signs of fungal inhibition.

Catalase activity

Catalase is a common enzyme found in nearly all living organisms exposed to oxygen which catalyzes the decomposition of hydrogen peroxide to water and oxygen. PGPRs with catalase activity can protect themselves against chemical, environmental and mechanical stresses by maintaining their reacting oxygen species (ROS) levels during stress (Fig. 4).

Figure 4. Evaluation of catalase activity. A drop of 3% hydrogen peroxide was added to a bacterial colony on a clean glass slide and mixed. Right: Production of oxygen bubbles indicates catalase activity.

Spore formation

Some PGPRs can form endospores to protect themselves against unfavourable environmental factors. Endospores can be stained with malachite green to identify the presence of spores in bacterial vegetative cells (Fig. 5).

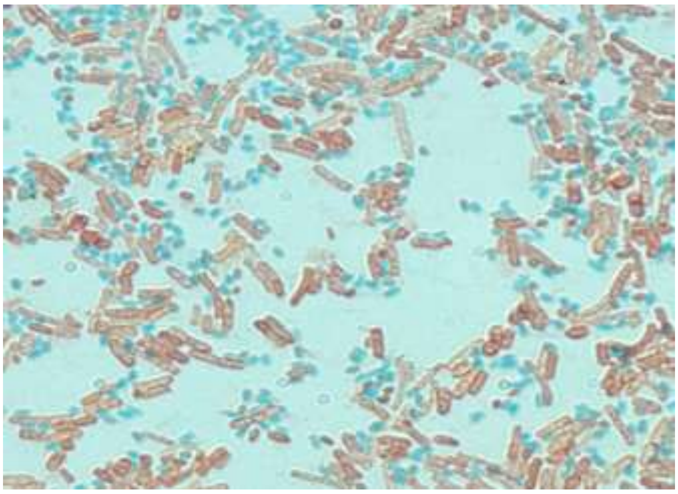

Figure 5. Evaluation of endospore formation. Stained bacterial isolates on a glass slide were viewed under microscope at 1000x magnification. Endospores appear green as a result of being stained with malachite green dye and vegetative cells appear pink/red as a result of being stained with safranin.

Biofilm

Biofilm formation is essential for successful colonization of plant roots by PGPRs as well as enhancing long-term survival. Biofilm formation was determined using the tube method (Fig. 6).

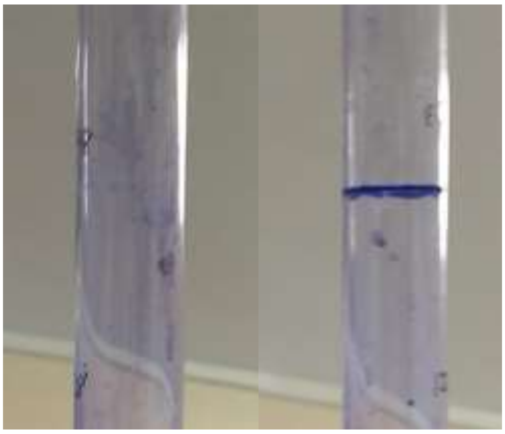

Figure 6. Evaluation of biofilm formation. Left: There is no film lining the wall, indicating no biofilm production. Right: There is a visible thick film lining the wall of test tube, indicating biofilm formation.

This study provided an insight into the bacterial community associated with sweet potato plants. We identified PGPRs with P-solubilizing, siderophore forming, fungal inhibition, catalase producing, and endospore producing abilities. These characteristics are considered as important PGPR traits and have been found effective in improving the growth of sweet potato plants. Further studies will be focus on the detailed molecular and functional characterization of these PGPRs for practical applications in the field.

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Strengths and significance of the ARC-VIMP Genetic Resource Collections

Compiled by Ms Ashika Jaimangal and Dr Michael Bairu, Plant Breeding Division, ARC-VIMP

Plant genetic resources, as defined by the Food and Agriculture Organization (FAO, 1983), refers to the entire generative and vegetative reproductive material of species with economical and/or social value, for agriculture of the present and the future, with a special emphasis on nutritional plants. These are also referred to as invaluable national assets as they form the basis of agriculture and global food security. In the last decade or so, we have seen a drastic increase in the global population, which has been met with a proportional increase in food production capacity. Unfortunately, increased food production has resulted in a significant decline in crop diversity since modern high-yielding, highly profitable crops are preferred by urban farmers over traditional varieties. Improved varieties are most often very uniform and lacks diversity, which poses a severe threat to long term global food security. Furthermore, this loss of genetic variation has implications on the ability of a species to adapt to biotic and abiotic stresses that may arise because of global climate change, leading to possible extinction of many species. It is therefore imperative that available genetic resources are urgently collected and conserved in line with policies, laws and institutional frameworks that promote and ensure sustainable use and access to these resources.

Diversity

The genetic resources collection at the ARC-VIMP is highly diverse; consisting of plant material for the vegetable, industrial, ornamental, medicinal, cosmetic, aromatic and essential oil industries. Currently, over 18 000 accessions of these plant species are maintained in genebanks, which equates to a significant amount of crop diversity that is being conserved along with these accessions. These national assets are characterized by their investment in relatively new areas of crop-based research and development (R&D), while maintaining a broader portfolio of crops. These include expansion of the R&D products and services on indigenous food crops, medicinal plants and essential oil crops. The ARC-VIMP is the go to institute for baseline information on these crops, as well as promoting collaboration and access to material. Requests for collaboration are received from across the globe. The ARC-VIMP is one of the very few institutions globally that is developing agronomic practices, breeding tools, and analytical protocols for food, medicine and cosmetics, as well as for other applications such as biomolecules for plant health and protection. It is equipped with world-class research facilities to undertake the R&D required across the value chain; from basic characterization and profiling of genetic material to the identification of biomolecules for commercialization and product development. These collections not only provide a service for R&D, but also contributes to capacity development as specialized laboratories and skilled personnel support the maintenance and conservation thereof.

Competitive advantage and impact

The ARC-VIMP has the only recognized sweet potato and potato breeding programmes in the country, with more than 10 000 accessions preserved *in vitro*. It is also the regional contact point for sweet potato related technologies, with no other institution in the country having the infrastructure set up to provide the services that the ARC sweet potato programme provides. This national scheme relies on the more than 350 sweet potato accessions in the ARC-VIMP national assets collection. The national sweet potato industry and farming households are 100% reliant on the ARC-VIMP for R&D, and the development/provision of improved varieties and disease certified planting stock. Numerous farmers have been trained on sweet potato vine production and they have gone on to successfully develop their own vine production enterprises (South African Vine Growers Association – SAVGA). The ARC-VIMP Sweet Potato Breeding Programme, that relies entirely on the genebank for provision of its breeding material, has produced a specific sweet potato variety named 'Bophelo', amongst others. A 66-gram serving of the boiled roots of this variety supplies the recommended daily allowance (RDA) of vitamin A for adults. This is significant considering that nutritional deficiencies are a major health problem in South Africa and the South African Child Gauge (2020) reported that children are now worse affected by malnutrition compared to 20 years ago.

The potato *in vitro* genebank is not only an integral and essential part of the ARC-VIMP Potato Breeding Programme, but is also the start of the entire potato seed certification scheme in South Africa, with the potato industry receiving its starting tissue culture material from the ARC-VIMP potato germplasm collection. The ARC-VIMP is also one of the few research organisations that has a strong onion breeding team that have recently developed male-sterile lines that are provided to private companies, such as UPOT and Hygro-

Figure 1. Various plant accessions maintained *in vitro* in long storage growth cabinets (a-b) and in the growth room (c).

Figure 2. Sweet potato crop accessions undergoing regeneration in the growth room.

tech under licencing for hybrid development. In addition, industrial and ethnobotanical research on economic plants is largely unique to the ARC-VIMP. Genetic characterisation of the pests and pathogens that make up the insect, viral, fungi and bacteria collection at the ARC-VIMP ensures that strains or accessions can serve as reference collections for future research. Medicinal plant research is pioneering the development of agronomic practices for cultivation, which will be the first of its kind to enable conservation through cultivation.

Global, national and industrial relevance

South Africa is the third most biodiverse country in the world. The ARC-VIMP national asset collections provide the platform for economic beneficiation and innovation by attracting international partners. In addition, the global community is putting treaties in place that require nations to conserve and share natural resources for food and agriculture. South Africa is a conservation hot spot with significant global relevance, and national assets from the ARC-VIMP collections are often requested by several private clients from abroad. Global exchange of plant genetic material contributes greatly to inter-cultural dialogues. Very often breeding efforts are most successful when there is access to plant genetic resources from various countries around the world. At the national level, the ARC-VIMP offers a quarantine service for imported agricultural material, wherein screening is conducted for quarantine pests as per the import permit requirements prior to the legal release into the country to mitigate phytosanitary risks. The ARC-VIMP national assets are also a key part in the development of production technologies for medicinal and aromatic plants. It also provides analytical services for plant tissue studies for the presence of nutritional and phytochemical biomolecules. New product development opportunities for various agri-companies start by screening the relevant national assets for suitability. Food processing companies stand to benefit from bred crop varieties that require less energy to process. This cost savings may even filter down to consumers at the end of the chain. In addition, several commodity organisations rely on the ARC-VIMP for starting material for agricultural production. The ARC-VIMP is a custodian of several genetic resources for the potato and sweet potato industries; this service is expanding to other crops, such as onion, where the ARC-VIMP breeding lines are now in use by the private sector for hybrid development.

Figure 3. Several ornamental plant species undergoing *in vitro* multiplication for supply to private clients.

Figure 4. Disease-indexed sweet potato (a and b), flower bulb (c) and indigenous vegetable (d) mother-stock plants maintained in the glasshouses.

Social, environmental and economic benefits

The conserved genetic material and other national assets are a treasure for several future generations. Sustainable utilization of these national assets also ensures that society can enjoy the benefits of better standards of living. The indigenous plant species conserved at the ARC-VIMP are under threat of extinction due to wild harvesting and habitat loss; sustainable funding and investment today will prevent these resources from extinction. Through breeding, consumers can enjoy the benefits of better nutrition through the availability of crops with increased nutrient value. The environment is currently under pressure from natural and man-made problems. One of the fundamental services that the national assets provides is protection of the environment through conservation and re-introduction of flora and fauna. Specifically bred crop varieties sometimes have multiple benefits. For example, drought-resistant varieties have the obvious benefit of contributing to food security, but also has an environmental benefit in that more water becomes available for crops that need it more. Economic benefits of national assets emanate from their role in the production of food, fibre, medicines/ drugs and bioenergy. Consideration should also be given to cultural and aesthetic values of conserved genetic resources to get a more holistic view thereof. Reliance on our own national assets also means that we rely less on having to import genetic material, which means reduced costs of production. Farmers can also benefit from new crop varieties bred by breeders for traits such as increased yield, drought-tolerance, disease-resistance, etc. The national assets in the ARC-VIMP are an attraction to international scientist and have resulted in several collaboration projects, often exter-

Figure 5. A few of the medicinal plant species that are currently maintained in the medicinal plants genebank.

nally funded.

Intellectual property (IP) generation
The national assets are the starting point for any innovation and IP generation; rigorous R&D using national assets precede this process. The ARC-VIMP is home to several crop varieties protected by Plant Breeder's Rights (PBRs). Research and development on conserved indigenous food and medicinal plants is also at an advanced stage to create IP-protected products and services. To date, the genome of one amaranth accession was sequenced, and metabolite and partial agro-morphological descriptions were done under the Biotechnology and Biological Sciences Research Council (BBSRC) funded collaboration with the University of York and the University of the North West (Mahikeng Campus). In addition, two potato varieties have been submitted to the Department of Agriculture, Land Reform and Rural Development (DALRRD) for awarding of PBRs and placement on the variety list will be done as soon as the New Unique Stable (NUS) tests are completed. Several research papers have also been published in various journals reporting on studies conducted on materials emanating from the ARC-VIMP genetic resources collections.

Figure 6. Some of the essential oil crop species that were most recently introduced into the medicinal plants genebank.

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Climate-smart irrigation practices for sustainable agriculture

Compiled by Batizi Serote [1,2], Hintsa Araya[1], Manaka Makgato[1], Khomotso Maboka[1], Phomolo Maphothoma[1], Stephen Amoo[1], Ian du Plooy[1] and Salmina Mokgehle[1]

Climate-smart irrigation technologies involve good irrigation practices for a given agro-climatic and societal context that takes explicit account of challenges and opportunities that may result directly or indirectly from different facets of climate change. These technologies include the use of rainwater harvesting, the tied contour ridging system, and drip and sprinkler irrigation. Adopting climate-smart irrigation technologies can reduce farmers' vulnerability to extreme weather conditions, thus making production and income generation more stable. Despite the well-documented effectiveness and feasibility of climate-smart irrigation technologies to cope with climate change in resource-constrained rural communities [1, 2], the adoption level remains low in the Limpopo Province. The adoption rate is particularly lower in the Vhembe district when compared to the Capricorn district. Smallholder farmers in the Capricorn district can access water from boreholes, dams and rivers for irrigation purposes, whereas in the Vhembe district, most of the farmers' plots are located at a distance away from reliable water sources. Other challenges such as access to limited input, lack of knowledge, poor capacity building, and lack of finance contribute to the low level of adoption observed in the district. A recent survey indicated that drip irrigation (Figure 1A) was adopted by 20% of smallholder farmers in the Vhembe district compared to the 69% identified in the Capricorn district.

In contrast, sprinkler irrigation (Figure 1B) was adopted by only 2% of smallholder farmers in both districts. This is understandable considering that sprinkler irrigation requires a high level of investment, and the water requirements are too high for these water-scarce areas. Some farmers, however, had limited or no interest in converting from traditional to climate-smart irrigation technologies. Therefore, based on the farmers' experience in crop production, their perception of certain technologies may be negative. The most common traditional irrigation method used in both districts was furrow irrigation (Figure 1C). It was used by 38% of smallholder farmers in the Vhembe district compared to the 16% in the Capricorn district. On the other hand, 40% of smallholder farmers in the Vhembe district and 12% in the Capricorn district relied on rain-fed agriculture. Rainwater harvesting could be a readily implementable technology for these farmers, as the system works entirely through gravity on sloped land or hillsides, and no pumps or electricity are needed.

Although most smallholder farmers have always responded to climate change through traditional methods such as flood and furrow irrigation, these coping mechanisms are insufficient for dealing with rapidly increasing medium to long-term impacts of climate change. The negative impacts of climate change are likely to be more evident in the Vhembe district because the district receives a low rainfall, ranging between 246 mm to 681 mm per annum. In contrast, the Capricorn district receives a fair amount of rainfall distribution that ranges from 300 mm in the northern half of the district to 1 000 mm in the southern half [3].

Therefore, failure to adopt climate-smart irrigation technologies will continue to introduce uncertainties such as food insecurity into the livelihoods of smallholder farmers, particularly those who have a higher dependence on rain-fed agriculture. In this context, the ARC-VIMP collaborates with the Water Research Commission (WRC) to fill the gaps that have been identified regarding the low adoption of climate-smart irrigation technologies in the Vhembe and Capricorn districts. Irrigation type consideration may be highly site-specific and not limited to a single method. A range of factors needs to be considered in selecting different irrigation innovations and water harvesting methods. These include the size of farms, water availability, and topographical features, such as field size, shape and soil type. Furthermore, a basic knowledge of how and why smallholder farmers have responded to past climate change trends is vital in enhancing current and future adoption strategies.

Acknowledgements: The Water Research Commission (Project no: C2021/2022-00247) and the Agricultural Research Council are gratefully acknowledged for funding and institutional support.

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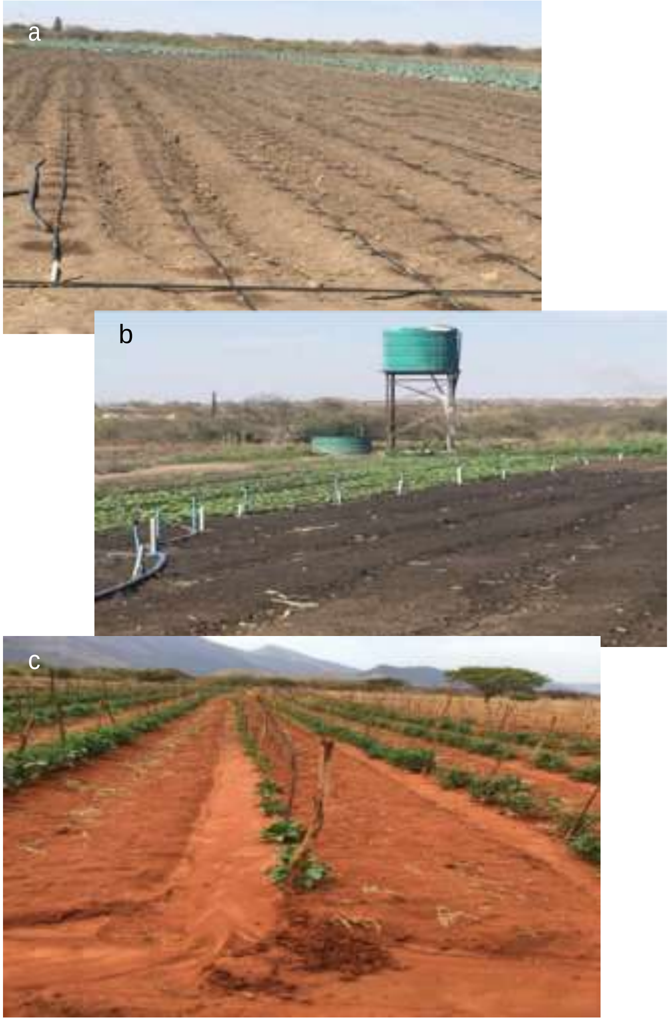

Figure 1. Cultivation of cabbage using drip irrigation (A), cultivation of spinach using sprinkler irrigation (B) and cultivation of tomatoes using furrow irrigation (C).

Fertilizer savings in a recirculating hydroponic system

Compiled by Dr Nadia Araya and Mr Makgoka Moremi, Crop Sciences Division, ARC-VIMP

In recirculating hydroponic production systems, crops are solely grown in water containing nutrients. Since the systems operate in soilless cultures, there is a need to supply all the essential macro- and micro-nutrients for optimum crop growth and development. These nutrients are often supplied through mineral or inorganic fertilizers, which are specially developed for the cultivation of plants in water. Such fertilizers contain specific formulations, which allow easy absorption and direct processing by the crops. Examples of commonly used, multi-component hydroponic inorganic fertilizers in South Africa are shown in Figure 1.

Figure 1. Multi-component water soluble hydroponic fertilizers: (a) Hygroponic and (b) Calcium nitrate.

Due to the soilless nature of hydroponics production, fertilizer is one of the major inputs into the system. Its high cost of acquisition, linked to low availability in local markets, very often poses a challenge to emerging commercial farmers for sustainable hydroponics production. As a result, there is a need to optimize fertilizer applications in hydroponics. The Agricultural Research Council (ARC), in partnership with Water Research Commission (WRC), initiated a project focusing on improving efficiencies of recirculating hydroponic systems, through appropriate management of nutrient solution electrical conductivity (EC) amongst other factors. Hence, a trial was conducted during the summer growing season of 2020/21 (November 2020 to February 2021) to identify an optimum EC level for sweet basil growing in a recirculating gravel film hydroponic system (Fig. 2).

The tested nutrient solution concentrations were set as follows: (1) 1.0 – 1.5 dS/m; (2) 2.0 – 2.5 dS/m; and (3) 3.0 – 3.5 dS/m. Multi-component inorganic fertilizers Hygroponic and Calcium nitrate were dissolved in water separately and subsequently placed into 100-L water tanks (Fig. 3). Adjustment of the nutrient solution concentration to the correct range was conducted manually through the use of an EC/pH combo meter. This was done periodically, following a depletion of nutrients due to either crop uptake or rainfall events, since the hydroponic system operated under a shade net.

The seasonal fertilizer applied to adjust EC levels from 1.0 to 1.5, 2.0 to 2.5 and 3.0 to 3.5 dS/m was 8, 14 and 20 g per plant of each multi-component fertilizer, respectively. Seasonal marketable yield was considerably lower under the 1.0 – 1.5 dS/m EC level (28 g/plant), compared to that at 2.0 – 2.5 and 3.0 – 3.5 dS/m which was unnoticeably different (147 – 155 g/plant) (Fig. 4). Therefore, the EC level of a hydroponic nutrient solution for growing sweet basil should be set at 2.0 – 2.5 dS/m. This can potentially save 6 g of either Hygroponic or Calcium Nitrate fertilizer per plant per season, contributing to increased income generation and profitability of farmers, which will lead to a more sustainable hydroponics production.

Figure 2. Sweet basil growing in a recirculating gravel film hydroponic system, under varying nutrient solution concentrations.

Figure 3. A 100-L tank used to hold the nutrient solution in a mini gravel film recirculating hydroponic system

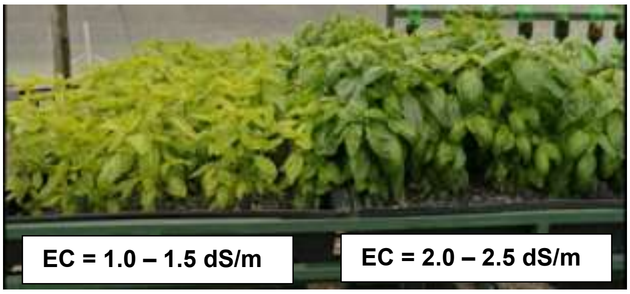

Figure 4. Sweet basil growth differences between EC ranges of 1.0 – 1.5 and 2.0 – 2.5 dS/m, under a gravel film recirculating hydroponic system at Roodeplaat, ARC- VIMP.

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Improving water use efficiency of recirculating hydroponic systems

Compiled by Mr Makgoka Moremi and Dr Nadia Araya, Crop Sciences Division, ARC-VIMP

The world's ever growing population and aggressive urbanisation continues to challenge sustainable living. Agriculture as primary food production industry is the largest consumer of fresh water and contributor to environmental degradation. The ability to increase food production, preserve water resources and environment has therefore been a priority for sustainability. South Africa, as a natural water scarce country, is not an exception to these global challenges. The industry considers hydroponics as a strategy to ameliorate these challenges associated with food production augmentation. The use of recirculating hydroponic systems is a typical example of such strategy, in which the nutrient solution is continuously re-used in the system, thus avoiding water and nutrient losses through drainage. Examples of such systems include the vertical bucket columns (Fig. 1a) and flood-and-drain system (Fig. 1b). Due to high heat susceptibility and absorption, growers usually rely on high water flow rates as a cooling mechanism in the rhizosphere. However, this has many implications on crop growth, yield and quality.

The Agricultural Research Council (ARC), in collaboration with the Water Research Commission (WRC), have initiated a project aiming to, amongst other aspects, quantify water consumption of high-value leafy vegetables and herbs, like basil, growing in recirculating hydroponic systems. Hence, a trial was conducted during the summer growing season 2020/21 (November to February) to quantify the water consumption of sweet basil growing under two different water flow rates (24 and 48 L/h) in a recirculating gravel film hydroponic system (Fig. 2). The 24 L/h flow rate resulted in considerably lower seasonal crop water consumption (8 L/plant) and higher water use efficiency (14 kg/m^3) compared to the

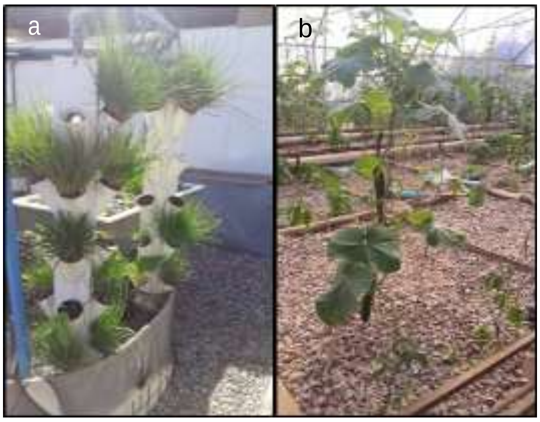

Figure 1. Cultivation of chives in a vertical bucket columns (a) and cucumbers in a flood-and-drain (b) recirculating hydroponic system.

Figure 2. A comparison between the effect of low (a) and high (b) water flow rates on growth of sweet basil affected after three harvests during the growing season 2020/21 at Roodeplaat, ARC-VIMP.

48 L/h flow rate (12 L/plant and 9 kg/m^3, respectively). High water flow rate in a gravel film recirculating hydroponic system is likely to cause increased water evaporation losses due to high water depth on the gravel beds, promotion of fungal diseases as a result of more humid conditions around the plants and slow crop growth as a consequence of lower crop water uptake. These findings suggest that water flow rates of recirculating hydroponic systems should be adjusted according to crop water requirements in order to attain maximum marketable yields, income generation and profitability, while saving water utilization through reduced evaporation.

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Medicinal Plant Research: Medicinal plant extracts keeps maize healthy

Compiled by Hlabana A. Seepe[1,2], Winston Nxumalo[2] and Stephen O. Amoo[1]

Smallholder farming remains a source of food and income generation for many households, especially in rural communities. Crops produced in this farming system include maize, sweet potatoes, soybeans, cowpea, spinach and tomatoes. Crop diseases are among the limiting factors during the production of these crops. Crop diseases may result in massive yield losses and can negatively affect crop quality. In smallholder farming, surplus seeds are kept, recycled and used for planting during the next season. *Fusarium* pathogens are among the microorganisms causing diseases both in the field and during post-harvest storage. Vascular wilt, maize head blight, seedling damping-off and root rot are common diseases caused by these fungal species. Additionally, some *Fusarium* species are capable of producing mycotoxins, which contaminate crops, seeds and fruits, and render them unsuitable for human consumption. Synthetic chemicals or fungicides are usually used in agriculture to control pathogens, however, these chemicals are sometimes out of reach and/or expensive to resource-limited smallholder farmers.

As an alternative to synthetic fungicides, we evaluated the potential use of leaf extracts from some available medicinal plants for possible prevention/control of diseases in smallholder farming systems. These include River bushwillow (*Combretum erythrophyllum*), Chinaberry tree (*Melia azedarach*), Velvet bush willow (*Combretum molle*) and Sawtooth oak (*Quercus acutissima*) (Figures 1-4). The results were promising, as indicated by their ability in controlling some *Fusarium* infections in maize, both in the field and during seed storage without phytotoxic effects. Leaf extracts can be sustainably prepared in different solvents, including water. Water is preferable, since it is readily available to the farmers. In order to improve the strength or activity, the extracts may be prepared by combining different plant species. Medicinal plant extracts present an alternative

Figure 1. Leaves of medicinal plants used for preparation of extracts. (a) River bushwillow (*Combretum erythrophyllum*), (b) Chinaberry tree (*Melia azedarach*), (c) Velvet bush willow (*Combretum molle*) and (d) Sawtooth oak (*Quercus acutissima*).

cheap strategy to manage *Fusarium* pathogens in the field and during post-harvest storage. They can be added to irrigation water, since they are considered safe for the growth of the crops. When used as a seed dressing agent, the seeds must be allowed to dry completely before storage.

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Medicinal Plant Research: Nutritional value of cactus pear

Compiled by Mologadi B. Mabotja, Stephen O. Amoo, Ian Du Plooy and Sonja Venter, Crop Sciences Division, ARC-VIMP

Cactus pear has a long history of use worldwide as a source of fruits and vegetables. Of the genus, *Opuntia ficus-indica* is the most economical, widely distributed and consumed species. The consumption of its fruits and cladodes is becoming common in different parts of the world, including South Africa. In South Africa, an estimated 1500 ha is cultivated for fruit production, with yields of about 15 000 tonnes and 3000 ha grown exclusively for fodder in commercial cattle production. The young cladodes are consumed fresh or cooked, as green vegetables in salads, soups and as commercial products, such as beverages and sauces. Both the fruit and cladodes are known for their nutritional value and the cladodes in particular are associated with high fibre content, including pectin, mucilage, cellulose and hemi-cellulose, which assist in the metabolism of glucose and lipids.

Figure 1. Spineless cultivars of cactus pear grown inside a glasshouse at the Roodeplaat campus, ARC-VIMP.

Cactus pear is a climate-smart crop with a high water-use efficiency and ability to grow under harsh conditions. The importance of this plant is particularly evident in arid and semi-arid environments where accessibility to most vegetables is relatively poor. Spineless cactus pear cladodes are an excellent alternative food source for humans and a drought-resilient feed resource for animal consumption, especially during drought conditions. The spineless cultivars are relatively non-invasive and legally allowed in South Africa for cultivation and trading unlike the spiny cultivars, which were included as a category 1 weed by the Conservation of Agricultural Resources Act, 1983 (Act No 43 of 1983) (CARA) and not allowed for planting and trading.

Figure 2. Field genebank of 42 Burbank spineless cactus pear cultivars grown at the Roodeplaat research farm.

In broadening the food base, extensive research focusing on species/cultivar nutritional traits and constituent bioactive compounds is of vital importance for germplasm characterisation, utilisation and selection in breeding and agro-processing programmes. The Agricultural Research Council - Vegetable, Industrial and Medicinal Plants (ARC-VIMP) campus at Roodeplaat currently maintains a cultivar bank of 42 Burbank spineless cactus pear cultivars comprising of *Opuntia ficus-indica* and *Opuntia robusta* uniquely found in South Africa. Extensive research is ongoing on the use of these spineless cultivars in food broadening projects in collaboration with partners such as the University of Free State and the Durban University of Technology. Although significantly varying amongst the cultivars, the spineless cultivar cladodes are good sources of important nutrients including potassium, calcium zinc and iron, and can be incorporated into functional foods in the battle against malnutrition or micronutrient deficiencies. The nutraceutical properties of the spineless cactus pear cladodes are further amplified by their strong antidiabetic and antioxidant activities.

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Youth getting their hands dirty during nursery management and landscape design training

Compiled by Phomolo Maphothoma[1], Erika Van Den Heever[1], Meshack Mofokeng[1] and Roelene Marx[2]

The ARC in collaboration with Department of Agriculture, Land Reform and Rural Development (DALRRD) has conducted technical and soft skills training on nursery management and landscape design. This initiative was aimed at developing agricultural skills in the youth group, so that they can be able to start their own independent agribusiness enterprises. Technology transfer in agriculture remains the fundamental tool for enhancing productivity, profitability and competitiveness in Africa's economic and rural agricultural development.

Nursery management training took place during December 2020 in Thabazimbi. In any successful crop production system, the propagation of quality plant material is the first step to be addressed. Seedlings are raised and maintained in the nursery before they can be established in the field. It is therefore important to acquire skills and knowledge on how to management a successful nursery. The youth were exposed to both theory and practical training, which covered the following modules: Basic botany, different growth media, fertilizer requirements, environmental factors, propagation techniques and nursery maintenance. Training manuals developed for this purpose were provided to the learning group as reference material.

Regardless of their educational background, the youth were exposed to the skillsets that will develop their operations along the agricultural value chain. With the acquired skills, youth can establish agribusinesses within the rural areas to boost the economy.

The training on landscape design was conducted in Bela Bela during January 2021. Landscape design focuses on the planning and designing of gardens, streets, parks and public spaces. Landscape design contributes to healthy living and wellbeing, while protecting natural environments and people. Successful landscaping does not just happen. It requires careful planning and some knowledge on landscape design. You have to consider your home's or office's architectural features, the character of the neighbourhood landscape, the effects you want to create and how you want to use your outdoor living space. It may take several years of planting and construction to achieve your goals, but the first step is proper planning and designing so that you can end up with what you want to achieve.

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Figure 1. Plants in a shade-net nursery.

Figure 2. Presentations and group discussions.

Figure 3. Practical on growing media, seedling preparation, and preparing stem cuttings.

Technology Transfer - December 2020 to March 2021

Scientific publications

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Post-graduate degrees

Mabotja. M.B. 2021. Nutritional value and bioactive properties of *Opuntia ficus-indica* cladodes. Master of Applied Science (Biotechnology), Durban University of Technology.

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Popular publications

Portia Ndou, Bridget Taruvinga and Ian du Plooy. 2021. Help! I can produce but cannot sell my vegetables: Cry for market access. Mzansi Agriculuture Talk on 15 February 2021. https://www.mzansiagritalk.com/archives/6114.

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Congratulations to Dr Hlabana Alfred Seepe from the Crop Sciences Division for obtaining his doctoral degree in 2021 from the University of Limpopo under the supervision of Prof W. Nxumalo and Prof S.O. Amoo.

The title of his thesis is 'Isolation and characterisation of antifungal compounds from medicinal plants that are active against selected *Fusarium* species', and below the introduction to his thesis abstract:

Fusarium species are among pathogenic organisms responsible for massive yield and quality losses in crop production. They cause crop diseases in the field and during storage, and some species are capable of producing mycotoxins which contaminate products and threaten consumer s' health. Conventional synthetic fungicides are available for the control of Fusarium pathogens, however, their applications have been restricted or discouraged due to their harmful effect on the environment, livestock and human health. There are also reports about fungal-resistance to available fungicides. Moreover, the synthetic chemicals are not affordable to smallholder farmers and to some extent, they are not recommended for applications in organic farming. As an alternative to these fungicides, selected medicinal plant species were investigated as sources of natural chemicals or compounds with potential to be developed into plant-based fungicides to control *Fusarium* pathogens. This study aimed to identify antifungal extracts among the selected medicinal plant species which could be used to develop plant-based fungicides to control Fusarium diseases. It also focused on isolation and characterization of antifungal compounds from selected medicinal plant species