ARC • LNR
Excellence in Research and Development

No. 15

Published:
13 March 2023

General enquiries
ARC-Vegetable, Industrial and Medicinal Plants
Private Bag X293
Pretoria
0001
South Africa

e-mail: vopiinfo@arc.agric.za
website: http://www.arc.agric.za

Inside this issue:

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)

Petite leafy vegetables: an emerging opportunity for improved nutrition and food security

Compiled by Beverly Mampholo, Neo Nyakane, Hintsa Araya and Mariette Truter

Microgreen vegetables constitute an exotic genre of edible greens found in the pleasing palette with immense potential for enhancing human nutrition. There is an upscale market for microgreens due to growing interest in society in healthy eating of fresh, functional food and ready-to-eat vegetables. Microgreens proffer substantial, readily available sources of essential minerals, vitamins, and proteins and offer peculiar polyphenols and antioxidant activities that contribute to the body's growth and maintenance [1]. Microgreens are caloric-dense food, the novel consumption is indisputable and inversely associated with a reduced risk of obesity, diabetes, and cardiovascular and neurodegenerative diseases [2], owing to their chemo-preventive properties, which are usually even higher than their mature counterparts. Microgreens are eaten raw and used as condiments to add exciting flavours and textures, and vibrant colours to soups, salads, and a variety of healthy homemade food preparations such as sandwiches, juices, shakes, and meat as garnish.

Promoting the consumption of microgreens
The benefits of microgreens are not just significant ease of cultivation and harvesting due to their short growth cycle, these nutrient-dense food sources can be produced with minimal input, without using pesticides; hence, they have low environmental impacts and a broad acceptance among health-conscious consumers. However, long-term storage and light exposure on microgreens is not recommended as it may affect the fresh weight, overall appearance, texture and organoleptic properties of microgreens. Therefore, more research is needed to study reasonable storage time and treatment to maximize the retention of phytochemical nutrients in microgreens in supermarket chains.

Figure 1. Varieties of microgreens.

Nutritional health benefits

Microgreens are the richest sources of dietary polyphenols which comprise important sub-classes of phytochemicals naturally found in plant foods. Polyphenols are phenylpropanoids synthesized by plants as secondary metabolites that function as potent antibiotic, antifungal, antiviral and antioxidant activity agents in adverse situations, such as in the presence of pathogens or under adverse climatic conditions [3]. Polyphenols are classified as simple phenolic acids (hydroxybenzoic and hydroxycinnamic acids) and flavonoids (anthocyanins, flavones, catechins, flavanols, flavanones, and isoflavones) exhibiting multiple biological effects particularly applicable to reducing the risk factors of various diseases linked with oxidative damage. Microgreens are effective in regulating blood glucose and weight loss control. Recently microgreens have been reported to present potential anti-inflammatory, anti-cancer, anti-bacterial, and anti-hyperglycemic prevention properties because of their content of minerals, vitamins, carotenoids, polyphenols, and glucosinolates [1]. Microgreens varieties are expanding based on standards of taste and health, in which the most utilized species are from the Cruciferae, Cucurbitaceae, Asteraceae, Chenopodiaceae, Lamiaceae, and Apiaceae families [4]. In addition, the benefits of microgreens are not just the significant ease of cultivation and harvesting but also due to their short growth cycle, but these nutrient-dense food sources can also be produced with minimal input, without using pesticides; hence, they have low environmental impacts and a broad acceptance among health-conscious consumers.

Varieties used for microgreens

Microgreens are tenderly soft and fresh vegetables produced from the seeds of abundant varieties of aromatic herbs and leafy vegetables. They are the seedlings of edible plants harvested 7–14 days after germination during the formation of cotyledons and the appearance of the first true leaves [5], as shown in Fig 1. Smallholder farmers can grow microgreens due to their high market value, popularity, and short production cycles. These vegetables offer a continuous supply of nutritious food due to the short-growing cycle, and year-round production makes these crops profitable for smallholder farmers and attractive to entrepreneurs. Microgreens are ideal to be grown indoors for home-scale production as well, with limited resources utilizing small space for daily household consumption to meet nutritional needs. It can easily be grown organically, with fewer disease problems and without external horticultural input inputs such as fertilizers and pesticides.

Figure 2. Microgreen mesclun salad.

Growing conditions

Depending on species and growth conditions, microgreens mainly depend on light with low humidity and good air circulation. Cool-season crops and some warm-season crops prefer slightly lower light conditions than herbs like basil. After planting the seeds, the trays are mainly exposed to light and watered daily until the first set of true leaves begins to emerge. However, recent research has shown the influence of environmental cultivation conditions on polyphenols and nutritional value. Several varieties of the same crop or different crops can be grown together to create attractive combinations of tastes, textures, and colours of mixed greens, popularly known as mesclun (Fig 2). The production of microgreens can be in conditions with day and night temperatures of 18 °C and 27 °C and relative humidity of 30 to 50%, respectively. Possible microgreens that can be grown could be green and red amaranth, kale, red cabbage, beetroot, coriander, parsley, spinach, kohlrabi, radish, red mustard, basil and spinach. Seeds can be sown in 200 cavity polystyrene trays. The growing media can include Hygromix® and vermiculite to cover the seeds after sowing. Seedlings should be irrigated at a rate of 1 g L^{-1} once daily, using fine-spray irrigation.

Harvesting and storage

Microgreens can be harvested when the representative average first true leaf in length is about 1 cm, using clean scissors or small hand pruners. Cutting height is crucial during harvesting to ensure that growth media particles do not contaminate the product. Microgreens are high-care vegetable seedlings that should be handled delicately. The harvested

Figure 3. Microgreens packaged in polyethene containers.

microgreens can be placed in polyethene containers (Fig 3) to protect against crushing and stored in the refrigerator at 5 °C for many weeks to prolong the product's shelf life, depending on the species. However, long-term storage and light exposure of microgreens is not recommended as they may affect their fresh weight, overall appearance, texture and organoleptic properties.

It is worth noting that growing microgreens are novel functional food sources that can offer huge potential for sustainably diversifying global food systems to achieve broader nutritional quality and improve human health in households. Therefore, a continuous supply of nutritional quality food forms comprehensive strategies to increase food availability and implement resilient nutritional safety and agricultural practices; hence they have low environmental impacts and a broad acceptance among health-conscious consumers. The potential use of indigenous vegetable as microgreens are being recognized in research. Apart from human nutrition, cosmetics is another niche industry that drives microgreens' growth and revenues.

References

1. Kyriacou M.C., Rouphael Y., Di Gioia F., Kyratzis A., Serio F., Renna M., De Pascale S., & Santamaria P. 2016. Micro-scale vegetable production and the rise of microgreens. *Trends in Food Science and Technology* 57:103–115.
2. Choe, U., Yu, L. L., & Wang, T. T. Y. 2018. The science behind microgreens as an exciting new food for the 21st century. *Journal of Agricultural and Food Chemistry* 66: 11519–11530.
3. Kilcians, A. and Gocmen, D. 2014. Changes in antioxidant activity and Phenolic Acid Composition of Tarhana with Steel-Cut Oats. *Food Chemistry*, 145, 777-783.
4. Turner E.R., Luo Y. & Buchanan R.L. 2020. Microgreen nutrition, food safety, and shelf life: A review. *Journal of Food Science* 2020;85:870–882.
5. Paradiso, V.M., Castellino, M., Renna, M., Gattullo, C.E., Calasso, M., Terzano, R.; Allegretta, I., Leoni, B., Caponio, F. & Santamaria, P. 2018. Nutritional characterization and shelf-life of packaged microgreens. *Food Function* 9, 5629–5640.

Contact: Dr Beverly Mampholo at MampholoM@arc.agric.za

Adoption of low-input soil moisture monitoring tools: Evidence from smallholder farmers in the Vhembe and Capricorn districts

Compiled by Batizi Serote[1], Salmina Mokgehle[2], Hintsa Araya[1] and Mariette Truter[1]

South Africa is the 30th driest country in the world, with crop production being the largest water user [1]. Research has indicated that 60% of the country receives less than 500 mm of rainfall per annum, whereas 21% of the other parts receive less than 200 mm. Consequently, resource-poor smallholder farmers, whose productivity is highly threatened by frequent droughts, are often affected the most. Being the backbone of the South African economy, agriculture has been identified as the sector that utilizes the largest volume of water through irrigation. However, as the availability of water resources, including changes in the volume and distribution of rainfall, continue to deteriorate over time, mainly driven by climate change and the growing population, irrigation requirements are escalating. Therefore, a substantial improvement in agriculture water use efficiency is required to maintain sustainable water use and ensure food security. This can be achieved by adopting low-input soil moisture monitoring tools that assist farmers in determining when and how much water to apply to crop fields. Furthermore, encouraging the cultivation of indigenous crops such as indigenous leafy vegetables (e.g. spider plants, cowpea, amaranth, etc.), leguminous crops (e.g. cowpea, Bambara groundnut, pigeon pea, chickpea, etc.), and grain crops (e.g. seed amaranth, pear millet, finger millet, etc.) that are already adapted to South African conditions and require minimum inputs should be exploited for income generation and the opportunity to be used as alternative crops by farmers.

In this context, demonstration trials of Bambara groundnut (*Vigna subterranea* (L.) Verdc.), okra (*Abelmoschus esculentus* (L.) Moench) and cowpea (*Vigna unguiculata* (L.) Walp.) were established in the Vhembe and Capricorn districts (Fig 1). This was done in collaboration with the smallholder farmers. The farmers were provided with an irrigation system (non-pressure regulated dripper) as part of the climate-smart technology. However, plant water status has remained one of the most challenging parameters for them to measure [2]. The majority of participating farmers do not have access to formal training, leading to farmers' inability to correctly determine irrigation needs which result in more or less than the crop water requirement. Therefore acquiring the relevant skills was revealed as the key factor when measuring feedback from specific management actions.

Figure 1. Planting of groundnut, Bambara ground and cowpea in the Vhembe and Capricorn districts.

To improve irrigation management, soil moisture monitoring tools were introduced to the farmers to create a learning system that would enable them to manage irrigation water losses and provide data that would assist in making better-informed decisions about when to irrigate and for how long [3]. Although there are a number of surrogate methods for measuring plant water status, the focus was on two of the simplest soil moisture monitoring tools; the chameleon soil moisture sensor and the wetting front detector (Fig 2). The chameleon soil moisture sensor is a portable hand-held reader connected to three or four sensors installed at different depths in the soil [4]. Each depth is represented by a light which gives a picture of soil moisture conditions from the top to the bottom of the root zone. For instance, the light can either be blue (wet soil), green (moist soil) or red (dry soil) (Fig 3). The wettable front detector (WFD) is a funnel-shaped device [5] that is buried in the root zone and has a mechanical float that alerts the farmer that water has penetrated to or past a specific depth in the soil. The WFD also retains a sample of soil water that is used for nutrient and salt monitoring.

Through farmer's days and exhibitions, the on-farm demonstration sites served as technology transfer sites for farmers. The expected outcome of this approach is that farmers who participated in the research gained first-hand knowledge of low-input soil moisture monitoring tools and indigenous crop production practices, thereby increasing community empowerment (especially women, who have greater control of food provision in the families). Technology transfer can reduce the impact of crop failure and improve resource use efficiency by smallholder farmers.

References

1. Fanadzo, M. & Ncube, B. 2018. Challenges and opportunities for revitalizing smallholder irrigation schemes in South Africa. *Water SA* 44(3): 436-447.
2. Stevens, J.B. 2006. Adoption of irrigation scheduling methods in South Africa. PhD thesis, Pretoria, University of Pretoria.
3. Abebe, F., Zuo, A., Wheeler, S.A., Bjornlund, H., van Rooyen, A., Pittock, J., Mdemu, M. & Chilundo, M. 2020. Irrigators' willingness to pay for the adoption of soil moisture monitoring tools in South-Eastern Africa. *International Journal of Water Resources Development* 36(1): 246-267.
4. Stirzaker, R., Mbakwe, I. & Mziray, N.R. 2017. A soil water and solute learning system for small-scale irrigators in Africa. *International Journal of Water Resources Development* 33(5): 788-803.
5. Melkamu, K. 2020. Evaluation of wetting front detector on irrigated conservation agriculture under vegetable production. MSc thesis, Bahir Dar, Bahir Dar University.

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

Author affiliations:
[1]Agricultural Research Council, Vegetable Industrial and Medicinal Plants (ARC-VIMP)
[2]School of Agricultural Sciences, University of Mpumalanga

Contact: Dr Hintsa Araya at ArayaH@arc.agric.za

Figure 2. A wetting front detector (WFD) was installed to improve water use efficiency at the farmer's demonstration site in the Vhembe district.

Figure 3. A chameleon soil water sensor was installed to improve water use efficiency at the farmer's demonstration site in the Capricorn district.

Brassica diseases and their control

Compiled by René Sutherland, Julia Mulabisana, Elsie Cruywagen and Michele Cloete

Introduction

The cabbage family or Brassicaceae include various important agricultural crops including Broccoli (*Brassica oleracea* var. italic), Brussels sprouts (*B. olerácea* L. var. gemmijera), cabbage (*B. olerácea* Li. var. capitata L.), cauliflower (*B. olerácea* L. var. botrytis L.), oil seed rape (*B. napus*) and broad leaf mustard greens (*B. juncea*). These crops are susceptible to various fungal, bacterial and viral diseases. The most important of these diseases will be described as well as the integrated management strategies that can be used to control these diseases.

Fungal diseases

White Mold

White mold, which is common in temperate regions of the world, is caused by *Sclerotinia sclerotiorum*. Under cool, moist conditions, it can be very destructive, with yield losses of up to 50%. Numerous plants in the cabbage family, as well as artichoke, bean, carrot, celery, groundnut, lettuce, pea, potato, soybean, tomato, sunflower, and numerous weed species, are among the pathogen's extraordinarily diverse host range. Sporadic illness outbreaks sometimes happen, and their severity varies depending on the time of year and the place.

Depending on the climate and farming methods, the fungus can survive as sclerotia in the soil for 3–4 years. The pathogen can then be disseminated by windborne spores once the sclerotia germinate and generate spores. The first signs of a cabbage infection are wet lesions on the stem and leaves closest to the ground; the infection quickly spreads and kills the plant. Typically, a white to grey fungal growth covers the head (Figure 1a), and minute, irregularly shaped black sclerotia are imbedded among the rotting tissues (Figure 1b). *Sclerotinia sclerotiorum* infections in seemingly healthy cabbage might cause rotting during transport and storage. Even at 0°C, the fungus can still continue to develop. Fields with mature plant infection cannot be saved. Prevention of disease and chemical control on young plants and seedlings should be the main goals of control strategies.

Fusarium Wilt or Cabbage Yellows

The fungal pathogen *Fusarium oxysporum* f. sp. *conglutinans* is the culprit behind this illness. Yellowing, stunting, and seedling death are common disease symptoms. Older leaves of plants wilt, become yellow, and drop from the base of the stem. Initially, symptoms are frequently only visible on one side of the plant (Figure 2). Vein discoloration on stems and leaf stalks is brown, as opposed to black as in Black rot. In the summer, when soil temperatures are high (between 27 and 30 °C), the disease is more common. The fungus has a very lengthy lifespan in the soil, therefor, seed treatment, crop rotation and application of fungicides **do not** help control Fusarium wilt.

Figure 1. a. Cabbage head infected by *Sclerotinia sclerotiorum*, with grey-brown necrotic and watery soft rot lesions on the leaves; b. white fungal growth and black sclerotia (arrow) developing between infected leaves. Photo 1a by Dr Julia Mulabisana and 1b by Dr Mariette Truter.

Figure 2. Yellowing and death of leaves on one side of the plant. (Photo: www.vegetables.cornell.edu)

Figure 3. Downy mildew on cabbage showing show typical "pepper spot" lesions (Photo: apps.lucidcentral.org)

Downy Mildew

Downy mildew, caused by *Peronospora parasitica* is a worldwide problem of crucifers. The disease favours cool wet weather conditions and can be very destructive under favourable conditions. Upper leaf surfaces show typical "pepper spot" lesions (Figure 3), while the lower surface of the lesions have a white fungal growth that can be seen with a hand lens. Infected cauliflower heads show areas of blackening. Downy mildew, although usually a problem in seedbeds, also attacks mature plants and infection is often followed by soft rot.

Clubroot

Clubroot, caused by *Plasmodiophora brassicae*, occurs worldwide and can be a very serious disease of crucifers. Infected plants typically have small heads, are stunted and occasionally wilted, and have leaves that are yellow or purple. Roots are abnormally swollen (Figure 4). Cool, moist, acidic soils are favorable for the disease, and spores can survive for a very long time in the soil. Farm equipment, footwear, tyres, and other items, as well as the movement of soil water, can all spread infected soil. Although it only currently affects a small portion of South Africa, this disease can be extremely damaging.

This disease is difficult to control and cannot be eradicated with any real effectiveness. Therefore, it's crucial to keep clubroot from infesting healthy fields. Clubroot can be reduced by the following:

- Practise crop rotation with perennial fodder crops for 7 years.
- Liming of acidic soils can help when there is a low clay content and a pH < 7.2. Too much liming, however, can result in nutrient deficiencies. Addition of calcium nitrate and boron to soils have also helped to reduce this disease in other countries.

Figure 4 Clubroot of cabbage.

Bottom Rot, Head Rot and Wirestem

Rhizoctonia solani causes three distinct illnesses in cabbage, namely bottom rot, head rot and wirestem. Older plants' stems will become blackened and girdled at the soil line as a result of **bottom rot**. These plants are frail, yield little heads, and have a chance of wilting and dying. Temperatures between 20 and 28 °C and damp environments are favourable for the disease development. Bottom rot infection in mature plants typically occurs when the plants are stressed.

In damp environments and while being stored, **head rot** can develop. Near the main stem, the outer leaves of the head wilt, turn pale, and eventually turn brown or black. The cabbage head's leaves are killed and let to wither at the base, but they are kept in place, creating the recognizable little, dark-coloured rotting head (Figure 5). Small brown sclerotia may develop and be visible on the head. Dark brown sunken spots are produced inside the head.

Wirestem is a disease affecting seedlings or young plants. In addition to *Rhizoctonia*, the disease can also be caused by *Fusarium* or *Pythium*. Stems are rotted at soil/medium level, but sometimes the seedling continues to grow, but the affected stem will be much thinner than the upper stem, hence the name wirestem. Wirestem can develop under cool temperatures, high humidity, compacted, wet soil and when seedlings are planted too close to each other.

Figure 5. Head rot of cabbage. Photo by Dr Julia Mulabisana.

Blackleg

This is a seed-borne disease caused by the fungal pathogen *Plenodomus lingam* (previously known as *Phoma lingam*) causing white/light brown lesions on the lower stem and on leaves, resulting in wilting and death of plants. The lower leaves of cabbage will typically have leaf spots that develop on the underside. Stem cankers develop (Figure 6) after the fungus grows down the plant from initial leaf spots. Small black dots (fruiting bodies) are visible within the older lesions. The margins around stem lesions are black/purple. Vascular tissues may turn black in colour before development of external black leg symptoms. As the lesion extends up and down the stem, the stem becomes girdled and blackened. Blackleg can also be a problem on seedlings when seedbeds are used for seedling production.

Figure 6. Blackleg lesions on lower stems (Photo: www2.ipm.ucanr.edu/agriculture/cole-crops/Black-Leg/)

Bacterial diseases

Black rot

The bacterial pathogen *Xanthomonas campestris* pv. *campestris* is the culprit behind one of the most devastating diseases of cabbages: black rot. For more than 120 years, the disease has been a major issue for growers. The pathogen prefers warm, moist conditions that are humid and rainy.

Black rot symptoms typically start with yellowing at the leaf margin and progress to the distinctive "V" lesion (Figure 7). In severe infections, the vascular tissue often turns black. The pathogen is mainly spread through infected seed or seedlings. Black rot can easily spread throughout the field by sprinkler irrigation. Additionally, the disease can persist in field crop debris as well as cruciferous weeds like yellow rocket and wild mustard.

Bacterial leaf spot

The bacterial pathogen *Pseudomonas syringae* pv. *maculicola* is responsible for this disease. Initially infected leaves will exhibit irregularly shaped lesions with a noticeable water-soaked border or brown or black spots between 3 and 10 mm in diameter (Figure 8), which will eventually merge to form larger irregular spots. Defoliation may result from a severe infection. Insects and splashing water, particularly irrigation water, easily spread bacterial leaf spot pathogen. When the weather is cool and moist, this disease is most common. This disease can survive the winter in plant waste and seeds. Bacterial leaf spot is a seed-borne disease.

Bacterial soft rot

The bacterium *Pectobacterium carotovorum*, formerly known as *Erwinia carotovora*, is responsible for soft rot of cabbage. This bacterium can enter the plant through wounds created tools or insect. Insects, contaminated equipment, movement of infected plant debris, soil, or polluted water are all ways that the pathogen can be transmitted. Typically, water-soaked lesions appear on the leaves and quickly turn brown or black (Figure 9). A distinct rotten odour develops along with the softening and sliminess of the affected tissues. Plants fall over as a result of soft rot at the base of the stem. When stems are sliced through, the vascular tissues appear brown. Soft rot is enhanced when plants have limited calcium and are exposed to extended wet spells or over irrigation. The majority of losses from *Pectobacterium carotovorum* are caused by post-harvest soft rot during storage or transit, while infection happens in the field before harvest.

Figure 7. Black rot of cabbage caused by the bacterial pathogen *Xanthomonas campestris* pv. *campestris.* Photo Julia Mulabisana © ARC

Figure 8. Bacterial leaf spot caused by the bacterial pathogen *Pseudomonas syringae* pv. *maculicola.* Photo Cornell University © 2022

Figure 9. Bacterial soft rot caused by the bacterial pathogen, *Pectobacterium carotovorum.* Photo Pestnet © 2022

Viral Diseases

***Turnip yellows virus* (TuYV)**

Brassica Stunting Disorder (BSD), caused by the *Turnip yellows virus* (TuYV), is the most commercially significant viral disease of cabbage. It was once referred to as the Beet western yellows virus. TuYV belongs to the Polerovirus genus (family Luteoviridae). It is transmitted by aphid species and the transmission is persistent, circulative but non-propagative. Infected plants may seem stunted and have purplish foliage (Figure 10). In addition, the possibility of side shoots, vascular discoloration in the stem and/or midrib of leaves has been seen. There have also been reports of the virus causing poor root development and lower yields.

Turnip mosaic virus (TuMV)

TuMV was previously known as *Cabbage black ringspot virus*. It belongs to the *Potyviridae* family, which has historically been linked to cabbage and cauliflower in South Africa. The majority of Brassica species are impacted. Numerous weeds, like wild radish, which can serve as infection reservoirs, are among its diverse host range. These viruses are rapidly spread to uninfected plants by aphid species, in a non-persistent way. Aphids pick up the virus as soon as they feed on a plant and transmit it immediately to healthy plants.

Severe mosaic symptoms (Figure 11 A&B) are characteristic of the disease. Additionally, young leaves develop chlorotic (yellow) ringspots, which ultimately turn into yellow or brownish spots surrounded by regular or asymmetrical necrotic (dead) rings. Necrotic rings also form during storage after harvest. Plants may also become stunted and malformed, and necrotic streaks, flecks (Figure 11C), and patches may also appear.

***Cauliflower mosaic virus* (CaMV)**

Brassicaceae family members are affected by this disease. Some CaMV strains can infect Solanaceae plants as well. It is spread by some species of aphids in a non-persistent way. Up to 50 % of the yield has reportedly been lost. The disease affects the growth of plants, flowers, and seeds (seed weight). Symptoms include vein clearing (yellow or white veins), mottling, and mosaic (lighter and/or darker green regions) (Figure 12). Additionally, necrotic patches may be seen, and plants may appear stunted.

Other viruses

Other viruses reported to affect the production of brassicas include *Tomato spotted wilt virus* (TSWV), *Radish mosaic virus* (RaMV), *Cucumber mosaic virus* (CMV), etc.

Figure 10: Disease symptoms of cabbage and oilseed rape plants infected with TuYV, showing some stunted growth and purpling of leaves. Photo Julia Mulabisana © ARC

Figure 11: Symptoms associated with Turnip mosaic virus on some Brassica species. (A) and B) are severe mosaic symptoms and (C) ringspots which later develops into yellow or brownish spots. Photo (A and B) Julia Mulabisana © ARC and (C) by Michal Manas, Wikimedia Commons, via CC BY-SA.

Figure 12: Vein clearing (yellow or white veins) symptoms associated with CaMV on some Brassica species.

Control of cabbage diseases

The key to managing plant diseases effectively is to follow an integrated disease management program. Factors to consider are listed below:

- Start with seed or seedlings that have been certified disease free and obtained from a reputable source. Seed can be treated with a fungicide, or by a hot-water to limit seed-borne diseases.
- Buy seedlings from a reputable nursery that practises plant hygiene. If using seedbeds, establish them away from old crucifer plantings. If infection occurs in the seedbed, destroy the seedbed immediately by deep ploughing.
- Use sterilized soil for seedbeds. Soil solarisation can reduce the amount of soil borne inoculum (e.g. sclerotia of *S. sclerotiorum*).
- Remove visible infected plants and destroy.
- Information about registered protective and curative chemicals and time of application for different diseases can be obtained from local authorities or chemical companies. Foliar chemical control is only effective if applied early in the growing season as sprays will not give effective control on mature plants.
- Apply protective chemical sprays when conditions favour development of foliar diseases. Copper-based products may be effective in preventing bacterial disease when used before plants are infected and with continued sprays at 7-10 day intervals after symptoms develop. Ensure coverage of lower leaf surfaces.
- Use drip irrigation or irrigate early in the morning and as far apart as possible. Leaves should be dry before night fall, as most pathogen spores requires high relative humidity or free water on the plant surface to germinate and infect. Try to keep the times between irrigation as long as possible. Don't over-irrigate.
- Adequate plant spacing will decrease humid microclimate conditions, and thus reduce infection levels.
- Avoid planting in infected fields. If unavoidable, avoid planting or working in these fields during very wet conditions.
- Apply strict sanitation. Wash down floors, tables, sterilize cutting implements, etc. with an effective disinfectant, e.g. quaternary ammonium products. Remove infected plant residues from the sorting/packing area regularly.
- Practise crop rotation with non-susceptible crops (e.g. cereals), for at least 3 years.
- Practice field sanitation; remove all plants/debris from infected fields or deep-plough in all residues.
- Remove all infected seedlings from the nursery and burn.
- Control weeds in and around production fields, as weeds can be a source of infection.
- Plant in well drained soils.
- Don't feed diseased plants to animals if manure is used on crucifer fields.
- Take great care that infected soil is not transported to healthy fields by implements, workers or surface runoff water.
- Plant resistant/tolerant cultivars where available.
- Try to avoid stressing plants, e.g. under-irrigating, over-irrigating, not controlling insect pests, applying incorrect herbicides.
- Do not over fertilize; maintain a balanced fertilization program. Avoid excessive application of nitrogen, and keep calcium and boron levels at an optimum.
- The use of sticky cards/traps (e.g. yellow and blue traps) will provide a way to detect the onset of infestation by insect vectors.
- 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.

Maintaining strong, healthy plants, planting recommended varieties, and keeping an eye out for any disease symptoms as they emerge are all effective management measures.

References

Brault, V., Herrbach, E., and Reinbold, C. 2007. Electron microscopy studies on luteovirid transmission by aphids. Micron 38, 302–312. doi: 10.1016/j.micron.2006.04.005.

Rimmer, S.R., Shattuck, V.I., and Buchwaldt, L (Eds.) 2007. Compendium of Brassica diseases. Department of Agriculture and Agri-food Canada.The American Phytopathological Society.

Scholelz, J. E., and Shepherd, R. J. 1988. Host range control of Cauliflower mosaic virus. *Virology* 162: 30–37. doi: 10.1016/0042-6822(88)90391-1.

Sutic, D. D., Ford, R. E., and Tosic, M. T. 1999. Handbook of Plant Virus Diseases. Boca Raton, FL: CRC Press.

Tompkins, C.N., Gardner, M.W., Thomas, H.R., 1938. Black ring, a virus disease of cabbage and other crucifers. *Journal of Agricultural Research* 57: 929-943.

Van Heerden, S.W., Pietersen, G., and Esterhuizen, L. L. 2016. First report of Turnip yellows virus associated with Brassica Stunting Disorder in South Africa. *Plant Disease* 100 https://apsjournals.apsnet.org/doi/10.1094/PDIS-12-15-1443-PDN.

Contact:
Fungal diseases
Dr Elsie Cruywagen at CruywagenEM@arc.agric.za

Bacterial diseases
Dr René Sutherland at SutherlandR@arc.agric.za

Viral diseases
Dr Julia Mulabisana at mjmulabisana@arc.agric.za

Survival of the potato bacterial wilt pathogen

Compiled by Rene Sutherland

Bacterial wilt (BW), caused by *Ralstonia solanacearum,* is considered one of the most destructive plant pathogenic bacterial diseases. Common symptoms include the wilting of foliage, browning of vessels, and stunting of the plant, ultimately leading to plant death. This soil-borne and xylem-invading plant pathogen causes high yield losses of many crops of economic importance. Knowledge regarding the survival of *R. solanacearum* in South African soils under different temperature conditions will be helpful to define control strategies for this devastating pathogen.

Soil samples were collected from two different localities, namely, Sandveld (Western Cape) and Dendron (Limpopo Province), and placed in Ziploc bags to maintain constant soil moisture. Soil types were sand from Sandveld and clay from Dendron. The soil was inoculated with *R. solanacearum* and incubated at 4 °C, 15 °C, 25 °C, and 35 °C, after which the survival of the pathogen was determined every 6 months. Survival was determined by direct plating, as well as inoculation in a recovery broth followed by plating out.

Figure 1. Soil microcosms were incubated under different conditions to determine the effect of temperature on the survival of *Ralstonia solanacearum*.

Results indicated that *R. solanacearum* survival is higher at lower temperatures in clay soil with a high water content. With an increase in temperature, there was a decline in the number of *R. solanacearum* cells. Survival in sandy soil was lower compared to clay soil. The ultimate goal of this project is to gain more knowledge regarding *R. solanacearum* survival in the soil over time, which will aid in developing an integrated control strategy against this notorious pathogen.

Figure 2. Numerous petridishes with selective media that were utilised to determine the survival rate of *R. solanacearum* at each time period.

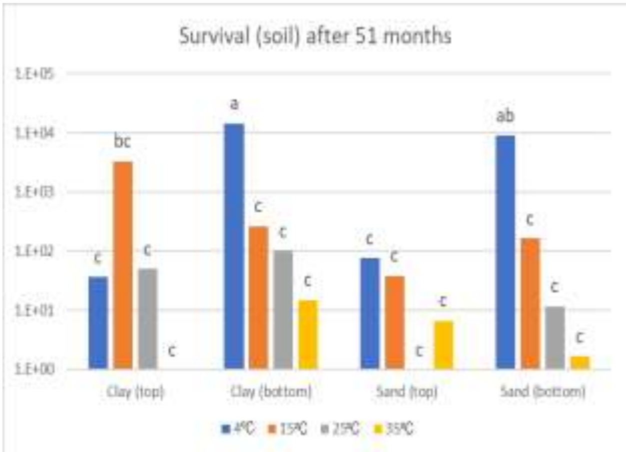

Figure 3. Survival of *Ralstonia solanacearum* in soil microcosms under different temperature conditions after 51 months incubation of the inoculated soil.

This project is funded by Potatoes South Africa.

Contact: Dr Rene Sutherland at SutherlandR@arc.agric.za

potatoes aartappels SA

Partnership with Seed Co Group: The African Seed Company

Compiled by Abe Shegro Gerrano, Michael Bairu, Willem Jansen Van Rensburg and Hintsa Araya

The indigenous vegetable breeding team at the Leguminous, Leafy and Fruit Vegetable Division, ARC-VIMP hosted an international seed company, SeedCo based in Zimbabwe on 18 - 19 September 2018 for the first time, to discuss future collaboration. The initial brain storming meeting and field visit were the start of an active collaboration and resulted in the recent signing of a Memorandum of Agreement between the parties. The main objective of the visit was to plan joint research and development, germplasm collection and exchange, technical and legal considerations (MTA), risk scouting (biotic and abiotic), proposal development for funding, development of seed systems, acquisition of funding/resources, Trademark and Branding Protection, as well as post-harvest handling/processing, i.e., value addition.

The following potential areas of collaboration were identified: the ARC, as a leading and premier science research institution in SADC, confirmed its commitment in collaborating with SeedCo R&D. Both the ARC and SeedCo have highly qualified conventional and molecular breeders specializing on different crops, who can all contribute to the agreed collaborations and both institutions have evaluation sites with full access to irrigation across the two countries that can be used in multi-location (mega environment) evaluations. The ARC agreed to assist SeedCo to achieve the sorted partnership, hence, a high-profile level engagement meeting involving the top management was planned during the visit. It was also indicated that SeedCo should collaborate with the ARC on smallholder farmer support initiatives to build the market, collaborate in capacity development and training of research teams and famers, as well as collaborating with the ARC in proposal development and the sourcing of funding. Finally, it has acknowledged that traditionally, gene banks distribute seed to support plant breeding in the formal seed system, namely, to agricultural research organizations and seed companies. The indigenous field crops, such as Bambara groundnut, cowpea, okra and amaranth, were visited by the international visitors (Figure 1).

Dr Abe Gerrano (senior plant breeder) and several research technicians are directly involved in the plant breeding research activities. Prof Michael Bairu, Research Team Manager of the Root, Tubers and Bulbous crops Division, also shared his experience in breeding with the team. The visit enhanced the sharing of knowledge and experience between the ARC and SeedCo on indigenous vegetable breeding, production and seed systems, which will enhance the contribution of both institutions to future food and nutritional security. This creates possibilities for future collaboration and the strengthening of existing collaboration in collaborative proposal writing in line with the existing MOU between SeedCo and the ARC.

Contact: Dr Abe Gerrano at AGerrano@arc.agric.za

Figure 1. From left to right: Dr Abe Gerrano (senior plant breeder for leafy, leguminous, and fruit vegetables), Prof John Derera (SeedCo), Dr Hintsa Araya (senior researcher for African leafy vegetables), Dr Learnmore Mwadzingeni (SeedCo), Dr Willem Jansen Van Rensburg (plant breeder for leafy and fruit vegetables).

Best Poster award for ARC-VIMP Intern

Compiled by Nadia Araya

Mr G. Sithole and Dr N.A. Araya presented a poster titled "Investigating *Moringa oleifera* yield and quality under different organic soil amendments practices", during the Combined Congress 2023, held at the University of Pretoria, South Africa. The authors were awarded the prize for the best poster presented at the event. Graig Sithole is a 21-year-old Diploma student registered at the Tshwane University of Technology. He is currently doing his internship at the Agricultural Research Council-Vegetable, Industrial and Medicinal Plants (ARC–VIMP), under the mentorship of Dr Nadia Alcina Araya. Mr Sithole began his experiential learning in April 2022, focusing primarily on the optimization of Moringa cultivation practices across South Africa. The research forms part of an external project funded by the Water Research Commission (Project No C2020/2021-00484, titled "Determining water use, water use efficiency and nutritional water productivity of Moringa under varying crop management practices"). This inspiring award-winning prize will serve as a motivation to young, as a rewarding scientific performance that will encourage them to make outstanding contributions to science.

Contact: Dr Nadia Araya at IbraimoN@arc.agric.za

First ARC Inter-Campus Research Conference

Compiled by Elsie Cruywagen

The first ever ARC inter-campus research conference was held 1-2 March 2023 as a hybrid event. The theme of the conference was: "The heat is on: the weird and wonderful research in ARC". Researchers and technicians from all campuses joined the event either online or in person at Central Office. The first keynote address was by the CEO, Dr Litha Magingxa on "Repositioning ARC For Challenge-Led Research & Food System Resilience" and set the stage for two days of engagement on the dynamic research work conducted within the ARC, as well as exploring collaboration opportunities. ARC-VIMP research was well represented by five speakers who presented the following talks:

Prof Stephen Amoo presented a talk entitled "Medicinal & Industrial Crops' R&D".

Prof Michael Bairu presented on "Advancing Root, Tuber & Bulbous Crop Research & Genetic Resources Management".

Dr Julia Mulabisana presented research in "Leguminous, Leafy & Fruit Vegetables' R&D".

Mr Phillip Steyn presented a talk on "Farmer Support, Commercialisation & Enterprise Development".

Dr Ian du Plooy gave a keynote address entitled: "Reflection on Research and Career Highlights".

Contact: Adri Laas at AdriL@arc.agric.za