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***ARC-Vegetable, Industrial and Medicinal Plants Newsletter***

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

# From food to feed: harnessing the versatility of cactus pear as a climate-smart crop

Compiled by Ebrahiema Arendse, Sylvia Neluheni, Nqobile Masondo and Stephen Amoo

Cactus pear cladodes

Sliced cactus pear cladodes

Cactus pear peal (waste)

Cactus pear (*Opuntia* spp.), also known as prickly pear or nopal, is a resilient and versatile succulent that thrives in arid regions, making it particularly well-suited to the South African climate. Cactus pear plants have been thriving in South Africa for over 300 years. The spiny cactus pear is highly invasive and is regarded as a weed in South Africa, whereas the spineless cultivars, despite their adaptability, remain an underutilized resource, with untapped possibilities waiting to be harnessed. The whole cactus pear plant, particularly the spineless cultivars, is edible, which includes the flat broad stems called cladodes or nopalitos, the fruit, and its waste products. The fruits are mainly used in South Africa, as the cladodes are not perceived as a food source. The cladodes are mainly sold in the informal markets and used as fodder. The cladodes could serve as an alternative food source with good nutritional value and as a health supplement ingredient when packaged for human consumption. The potential use of cladodes is enormous in a country where food and water sources decrease continuously.

*Opuntia* spp. cladodes are a nutritionally rich resource with varying compositions depending on their maturity. They contain essential nutrients, including carbohydrates (69.70±2.35 g/100 g dry mass, DM), ash (15.77±1.61 g/100 g DM), fiber (8.16±1.41 g/100 g DM), protein (4.43±0.81 g/100 g DM), and lipids (1.39±0.17 g/100 g DM). Additionally, they are a good source of calcium, magnesium, potassium, and phosphorus (Mabotja et al., 2021a). The slightly acidic taste of cladode juice (pH 4.6) lends it a sour flavour, and the high calcium and fiber content makes cladodes more nutritionally valuable. A number of traditional foods are prepared from *Opuntia* spp., including fruit-based products such as jams, juices, and nectar, dried fruit, juice concentrates, syrups, and liquors. A recent article by Mabotja et al. (2021b) showed that cactus pear cladodes have potent phytochemical, antioxidant, and antibacterial properties, thus making them a suitable candidate for the formulation and development of products. Consumers are increasingly interested in products derived from the cactus pear plant due to their potential nutraceutical benefits. Currently, at the Agricultural Research Council–Vegetable, Industrial and Medicinal Plants (ARC-VIMP) agroprocessing facility, several products have been developed and tested by processing the cladodes. These products include herbal-

infused smoothies and juices.

Cactus pear has long been celebrated as a source of human nutrition, appreciated for its delightful taste and health benefits. However, its applications go far beyond our plates. South Africa's agricultural landscape holds vast potential for harnessing cactus pear's versatility, especially in the realm of animal feed. In a country often challenged by water scarcity and fluctuating forage availability, cactus pear provides a reliable and sustainable source of nourishment for various livestock, including cattle, sheep, and goats. The economic benefits of using cactus pear in animal feed are significant, as it not only helps reduce the cost of livestock maintenance, but also enhances animal health and productivity. Cactus pear cultivars have been identified as a significant source of maintenance feed in several studies (De Waal, 2015). The use of sun-dried cactus pear cladodes has the potential to provide 25% of the basic feed resources required by South Africa's commercial ruminant feed manufacturing sector (De Waal et al., 2014). Cactus pear cladodes, when fresh, can also be used to make silage. *Opuntia* spp. By-products or peel waste, also have the potential to improve milk production and nutrient digestibility in sheep (Morshedy et al., 2020). To minimise waste from products developed for human consumption, the ARC-VIMP researchers aim to further process the peel waste into animal feed while supplementing it with other nutritionally important crops.

Beyond their significance in the realms of the food and feed industries, cactus pear presents a multitude of opportunities across various industrial sectors. The pharmaceutical industry stands to benefit from cactus pear through the extraction of mucilage for gastric mucosal protectants, and the creation of tablets and capsules from cladode powder and flower extracts. The cosmetic industry can harness the plant's potential to produce creams, shampoos, and lotions derived from cladodes, offering natural and sustainable alternatives. In the food supplement industry, cactus pear offers a source of high-quality fiber and flour derived from its cladodes, promoting health and nutrition. Moreover, cactus pear has applications in the natural additives industry, providing gum sourced from cladodes and natural colorants from their fruits. The construction industry can explore binding compounds derived from its mucilage and cladodes, while the energy sector has the option to generate biogas through the digestion of cladodes and factory waste streams, or alternatively, utilize lignified cladodes as a renewable source of fuelwood. The versatility of cactus pear extends their utility into multiple sectors, presenting a sustainable and eco-friendly resource with wide-ranging applications.

The utilization of cactus pear cladodes as a sustainable food and feed source holds immense potential for South Africa, addressing not only food security, but also economic opportunities and environmental sustainability. As the researchers at the ARC delve deeper into the realms of research and development, the exploration of cladodes' possibilities could lead to innovative products and practices that transform how South Africans view and consume this remarkable succulent. By addressing the gaps in research and development, South Africa can unlock the full potential of cactus pear cladodes and harness the untapped resources that lie in their sustainable cultivation and consumption.

Yogurt-infused cactus pear smoothies.

Herbal-infused cactus pear juice.

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# Red spider mites as vegetable pests

Compiled by Diedrich Visser

**Background**

Mites are usually less than one millimetre in length, and colonize almost every habitat on earth, including the soil, water, other organisms, our houses and plants. Mites vary greatly in their ecology and behaviour, some are predatory, some live on dead organic material, and others are plant feeding. A few plant feeding species are economically important plant pests. Mites are not insects, but are closely related to spiders and scorpions, all belonging to the Class Arachnida. Adult insects usually have six legs, whereas adult arachnids usually have eight legs.

The red spider mites are the most common and well known plant feeding mite pests. Most spider mite species prefer to live on the undersides of leaves where they spin webs under which they feed and multiply. Both males and females, and usually numerous small round eggs, occur in the colonies. The webs enhance the living space of the mites (protection and shelter). However, under high population densities the mites will occupy all plant surfaces. When their living space becomes too crowded or feeding sites deteriorate, they will congregate on the highest parts of the plant to spread to new areas by wind or animals. This is especially true in the case of the spider mites which also spin elaborate webbing over entire plants to facilitate movement and dispersal. Some spider mites, however, do not spin webbing at all.

**General damage symptoms**

Plant feeding mites have piercing and sucking mouthparts. They first damage plant tissue with their stylets and then suck out the cell contents. The most common damage symptoms are those inflicted by spider mites in the genus *Tetranychus*. Their feeding causes leaves to get a speckled appearance with small white and yellow spots increasingly replacing the green colour of the leaf as the mite populations and feeding increase. Although most feeding is on the undersides of leaves, the symptoms are also visible on the upper leaf surfaces. Later this chlorotic stippling expands and the leaves get a scorched appearance. Such leaves quickly turn brown and die. Mites typically gather on the upper dead or dying leaves in masses, and it is usually only then that they are noticed. By this time control is usually too late and most plants will die. Mites do not emerge homogenously in fields, but rather infest plants in clusters in specific areas. These clusters (or infestation spots or patches) are not always evident. The infestations may also move in from the edges of a crop. However, when they are noted, it is usually too late because re-infestation from here to the rest of the field has frequently already begun. Red spider mites prefer hot and dry conditions.

**Control**

Red spider mites are one of the most difficult vegetable pests to control. It is only certain pesticides that give adequate control while most alternative control measures help only partially. When applying pesticides, it is important to ensure good coverage of the lower leaf surfaces. The mites

Spider mites are usually only noticed once they reach very high numbers and moving on webbing between leaves.

Most mites are extremely small, with spider mites usually less than one mm in length.

not only hide on the lower leaves, but some also spin elaborate webbing under which they are protected from contact pesticides. It is important to use high water pressure while applying pesticides to ensure smaller droplets that penetrate deeper or to use systemic acaricides that penetrate leaves also from above. However, eggs will not be killed with systemic acaricides and regular inspections and follow-up spraying may therefore be needed to stop mite re-infestations. Most acaricides, however, will also kill natural enemies. Several natural enemies are known to control mites to different degrees, of which predatory *Phytoseiulus* mite species, are the most well-known.

A few external factors may enhance the susceptibility of some crops as hosts of plant feeding mites. This includes plants receiving excessive nitrogen fertilizers, and plants that are stressed by low moisture or high temperatures. Some sources also reported that plants growing in dusty places, e.g. alongside dusty or farm roads, are prone to mite infesta-

tions. Where these factors can be eliminated, mite numbers may be reduced.
Infestation clusters may appear in the middle of the field due to single mites dispersing, usually with wind, to these isolated spots. These clusters must be found and spot treated with acaricides before a general application over the remainder of the field.

Weeds, especially solanaceous weeds, are alternative hosts for mites and may also be a source of mite infestations. Remove or kill all weeds in the vicinity before a crop is planted. Another important means of infestation is by movement of humans, animals and implements. Mites are brushed off onto any moveable object in infested fields and may drop off at any time, infesting new areas in the field in the process. It is therefore advised to visit uninfested fields before an infested field is visited, and to limit movement of people and equipment in infested fields.

Spider mites overwinter as mated and gravid females. These females do not feed, but hide in secluded places like soil cracks, crevices in glasshouse structures and in crop debris, after crops are harvested at the onset of winter. As soon as temperatures increase after winter and new crops start growing in the greenhouse, these overwintering females will move onto the plants and start new infestations. However, during moderate winters the mites will feed continuously if plants are available. It may be advantageous to spray all greenhouse surfaces during off seasons in an effort to eliminate these overwintering females. An insecticide with contact and/or a fumigation action would be most effective.

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Spider mite infestations frequently start in isolated areas (e.g. the circled area), from where the infestation spreads.

Spider mites may completely destroy tomato plants in a matter of weeks.

# Naturally occurring entomopathogenic nematodes as biocontrol agents

Compiled by Abongile Nxitywa

**Introduction**
According to entomologists, "Not all pests are insects, and not all insects are pests". This means that some insects are helpful and do not harm or impede plants. Some of these insects can also be utilized as biological control agents, which can be included into an integrated pest management plan, since they feed on other insects. Nematodes exhibit similar phenomena in that not all of them are plant parasitic; some are non-plant parasitic. A group of non-plant parasitic nematodes are known as entomopathogenic nematodes (EPNs).

Entomopathogenic nematodes are minute, free living organisms that parasitize and kill insect pests. The term “entomopathogenic” is self-explanatory as “entomon” refers to insects and “pathogenic" means causing a disease. Entomopathogenic nematodes are used worldwide as biological control agents to control insect pests.

In as much as the use of pesticides is often preferred as a quick solution for the control pests, pesticide resistance development is amongst the major challenges that the South African crop protection industry faces. The use of chemical pesticides raises additional issues related to human, animal, and environmental health. Consequently, having an integrated pest management plan that includes EPNs as a component of a biological control agent is crucial.

The familiarity of EPNs in South Africa is still in its infancy and is less understood than other biological control strategies. South African producers are more familiar with the plant parasitic nematodes, especially the root damaging nematodes (lesion- and root knot–nematodes).

**How do EPN's work?**
Entomopathogenic nematodes parasitize a broad variety of

insects and are mostly members of the Heterorhabditidae and Steinernematidae families. The stage of the life cycle known as infecting juveniles (IJs) causes death by entering an insect through its cuticle or other natural openings, such as the mouth, spiracle, or anus. Once inside the insect, the IJs release their associated bacteria into the haemocoel. Toxins released by the bacteria and nematode cause death within a space of 24 to 48 hours. As the nematodes begin feeding on the gut tissues of their hosts and develop into adults, they will reproduce and multiply exponentially inside the insect. The new IJs will depart the cadaver in search of a new host when the gut food supply is exhausted.

**Status of EPN's in South Africa**

In Europe and the United States of America, formulated EPNs are commercially sold for use against pests. However, the use of EPNs is still relatively new in South Africa, and not all producers are familiar with this biological control agent. South African research scientists are in the process of developing EPN-based biopesticides for commercialization using local isolates. Recent research on mass production using in vitro culturing, and the formulation of EPNs using diatomaceous earth and encapsulation within alginate calcium has been promising. Since EPN commercialization is still in its early phases, and additional field testing is required before a product can be registered, it will probably be a while before they will be available on a larger scale.

**Interesting facts about EPNs**

- Easy and inexpensive to culture.
- They actively search for their host in the soil.

Infective juvenile entomopathogenic nematodes emerging from the larvae of *Tenenbrio molitor.*

- During application, protective clothes are not necessary.
- Standard chemical spraying equipment can be used for application, no special equipment is needed.
- Takes less time than other biologicals to kill the host.

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# Pest and disease survey in Gauteng Agri-Parks

Compiled by Elsie Cruywagen, Julia Mulabisana, René Sutherland, Diedrich Visser, Juanita Engelbrecht, Zama Nkosi, Sinethemba Nkosi and Abongile Nxitywa

DALRRD has funded a project aimed at improving integrated pest and disease management strategies for a diversity of crops. One work package of this project is focused on increasing the capacity of small-holder farmers at Agri-Parks. To facilitate this aim, scouting surveys will be conducted for pests and diseases on all crops at the Agri-Parks throughout the different growing seasons.

During October and November 2023 surveys were conducted at the Soshanguve and Rooiwal Agri-Parks. Symptomatic plants were collected and identification for fungal, bacterial and viral pathogens are underway. Several insect pests were also collected for identification.

Outcomes of this project will include knowledge of pests and diseases affecting crops grown in the Agri-Parks and development of integrated pest and disease management (IPM) control measures. Knowledge transfer of these targeted IPM strategies will be done through training events, pamphlets and educational videos. Evaluation of these control measures will be done through continued scouting and interactions with farmers.

Viral symptoms on Swiss chard (left) and coriander (right).

Farmers at the Agri-Parks or community gardens are welcome to contact us for consultations regarding pest and disease problems.

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Potato lady beetle causing damage on Swiss chard.

# Scented geraniums at the ARC-VIMP

Compiled by WS Jansen van Rensburg, H Araya, and SO Amoo

Scented-leaf geraniums refer to *Pelargonium* species that have aromatic leaves. The leaves release their scent when their leaves are brushed or crushed. The fragrance is released by glands at the base of their leaf hairs where the scented oil is formed. This is the oil that is being distilled into essential oils. The main chemical constituents of geranium essential oils are linalool, geranyl formate, citronellol, and geraniol, although many other chemical constituents are present that contribute to the fragrance of the oil. The South African National Biodiversity Institute (SANBI) lists at least 20 *Pelargonium* species in their PlantZAfrica page (http://www.plantzafrica.com/). There are also a wide range of scents, which include rose (*P. capitatum, P. graveolens and hybrids*), lemon (*P. crispum*), pine (*P. denticulatum*), nutmeg (*P. fragrans*), coconut (*P. grossularoides*), apple (*P. odoratissimum*) and peppermint (*P. tomentosum*), amongst others. Rose geranium is the best known scented geranium. However, several species have the rose scent. *Pelargonium graveolens* is the geranium species that is most commonly cultivated for the extraction of the sweet rose smelling essential oil.

Used in aromatherapy applications, geranium essential oil is known to reduce feelings of stress, anxiety, sadness, fatigue, and tension, thereby enhancing the general sense of well-being and relaxation, while offering relief to those suffering from insomnia. Its sweet, uplifting floral scent makes it an ideal ingredient in the manufacturing of soaps and cosmetics, such as creams and perfumes. Used cosmetically or topically in general, geranium essential oil is reputed to contribute to the health of the skin cells and ultimately the health of the complexion.

Figure 1: The deeply lobed skeletal leaves and showy flowers of *Pelargonium radens*. The dark markings in the flowers are very prominent.

Figure 2: The lobed leaves and small flowers, born in tight clusters, of *Pelargonium graveolens*.

The ARC-VIMP has built up a collection of scented geraniums as part of the Department of Science and Industry funded project on the promotion of essential oil enterprises for small holder farmers. The initial focus was only on rose geranium, however, the scope has extended to all scented geraniums since last year.

Morphologically, the scented geraniums vary quiet a lot. The leaves of the scented geraniums are mostly green, although there are some variegated varieties, especially in *P. crispum*. The leaves vary from deeply incised skeletal leaves of *P. radens* (Fig. 1) to lobed leaves of *P graveolens* (Fig. 2) and *P. quercifolium* (Fig. 3) to almost round like the leaves of *P. odoratissimum* (Fig. 4) and *P. fragrans* (Fig. 5). The leaves are various shades of green or even grey like in *P. fragrans* (Fig. 5) or variegated like in *P. crispum* varieties. Some leaves are covered in soft hairs like in *P. tomentosum* (Fig. 6) or coarser hair like in *P. quercifolium* or even short velvety hairs like in *P. odoratissimum*.

The flowers have shades of mauve, pink, purple, or white with dark markings (Figs 1 to 7). The flowers are borne in clusters with varying numbers of flowers. The flowers vary in size from the small flowers of *P. tomentosum* and *P. grossularoides. Flower colour may vary within a species, for example P. capitatum* can have white, light or dark pink flowers (Fig. 7).

Although the current collection does include quite a lot of diversity, the collection needs to be expanded to include more species, as well as specific cultivars. Especially the highly sought after rose geranium cultivars. The composition and quality of all the accessions needs to be established. These oils can be used in products like scented soaps, scented candles, aroma therapy oils and oil diffusers.

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Figure 5: The grey leaves of *Pelargonium fragrans*.

Figure 3: The lobed leaves of *Pelargonium quercifolium* are reminiscent of oak leaves. The flowers are large and characteristically borne in groups of two.

Figure 4: The almost round leaves of *Pelargonium odoratissimum.* The small white flowers are borne in loose clusters.

Figure 6: The hairy leaves of *Pelargonium tomentosum.*

Figure 7: different flower colours of *Pelargonium capitatum.*

# Nordic Natural Products Conference 2023

Compiled by Dr Dashnie Naidoo-Maharaj

Dr Dashnie Naidoo-Maharaj presented at the Nordic Natural Products Conference 2023, which took place at the University of Helsinki in Finland from 14 to 16 June 2023. The presentation was on high throughput screening and hyphenated analytical technologies for accelerated identification of biologically active compounds from South African plant biodiversity. Using this approach, the scientific data of the South African France bilateral project was presented, which involves collaborators from the ARC, University of Pretoria, Early Drug Discovery Group and the Curie Institute.

A benzophenanthridine alkaloid was identified as an anticancer compound with good activity against prostate cancer (IC50 of 1.85 µM against the DU145 cancer cells; IC50 of 3.30 µM against the PC3 cancer cells). The compound will undergo in-vivo pharmacokinetics and pharmacodynamics studies. The ARC-VIMP will be involved in supply of plant material for isolating the active compound for in-vivo and preclinical research. The latter involvement will ensure a sustainable supply of good quality plant material, with the active compound concentration determined.

The conference was a good opportunity for networking to form collaborations with other institutes. The delegates, from all parts of the globe, were interested in the ARC's role in different stages of plant propagation, focusing on high quality and high yield, cultivation studies and field trials for the survival of high quality plants, and training of communities to establish businesses for the commercial supply of plants.

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From left to right: Dr Naidoo-Maharaj with Prof David J. Newman, Retired Chief from NIH/NCI, Prof Heikki Vuorela from University of Helsinki, and Prof. Moses. K. Langat from Royal Botanic Gardens Kew.


Dr Naidoo-Maharaj presenting on the natural products drug discovery approach from past to present.

# ARC well-represented at the African Plant Breeders Association Conference

Compiled by Dr Abe Gerrano

The Agricultural Research Council (ARC) participated in the African Plant Breeders Association (APBA) Conference 2023, that was held at the Mohammed VI Ploytechnic University (UM6P), Benguerir, Morocco from 23-26 October 2023. Around 400 delegates from 58 countries participated in the conference. The ARC delegates were Dr Nthabiseng Motete (Group Executive: Crop Sciences), Dr Kingstone Mashingaidze (Principal Researcher, ARC-Grain Crops), Dr Abe Gerrano (Senior Researcher, ARC-Vegetables, Industrial and Medicinal Plants), Dr Zaid Bello (Researcher, ARC-GC), and Mr Moshieng Ntswane (PhD student, ARC-GC). The ARC delegates showcased their research at the conference through oral and poster presentations. The delegates met with different governmental and private companies, research institutions and university delegates for future collaboration and to market the ARC internationally.

The conference brought together international scientists and experts representing different national and international institutions (CGIAR research centers, universities, research institutions, private companies, donors, etc.). It presented a good opportunity for plant breeders, researchers, students, private companies, as well as national agriculture policy makers to share their knowledge and discuss their research findings and recent achievements. Such interactions will help in preparing strategies and partnerships to tackle future challenges in research and development for the African continent and provide opportunities for potential collaborative activities with the theme 'Leveraging Genetic Innovation for Resilient African Food Systems in the wake of Global Shocks'.

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From left: Mr Moshieng Ntswane (PhD student, ARC-GC), Dr Nthabiseng Motete (GE: Crop Sciences), Dr Abe Gerrano (Senior Researcher, ARC-VIMP), Dr Zaid Bello (Researcher, ARC-GC), and Dr Kingstone Mashingaidze (Principal Researcher, ARC-GC).


From left: Dr Nthabiseng Motete (GE: Crop Sciences), Dr Abe Gerrano (Senior Researcher, ARC-VIMP), Mr Moshieng Ntswane (PhD student, ARC-GC), Dr Zaid Bello (Researcher, ARC-GC), and Dr Kingstone Mashingaidze (Principal Researcher, ARC-GC).