Production Guideline for SUMMER VEGETABLES
Production guideline for winter vegetables
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Rising food prices have become a global phenomenon, and South Africa is not immune to it either. It is a crisis that has gripped even the most developed countries and is raising concern about the effects on the world economy.

The constant increases are mainly the result of rising input costs, the exchange rate, competing demands for grains and climate change, as well as other factors.

Technology transfer
Over the years, the Agricultural Research Institute (ARC) has engaged in various initiatives that focus on technology transfer and on meeting the needs of the second economy.

This focus lies in the areas of increased agricultural productivity, improved food quality, efficient use of energy through deployment of renewable energy sources, the design of solutions to mitigate the effects of climate change, broadening the food base and the sustainable agricultural use of natural resources such as water, as well as the quality of soil and grazing.

The ARC has been instrumental in the success of grain, horticulture, livestock and some industrial crops as commercial products. The Council has provided information, knowledge and technical know-how emanating from research, technology development and technology transfer to the agricultural sector.

In addition, it has contributed towards the sustainable use of natural resources through research, technology development and information to enhance planning and decision-making.

Production guideline
It is expected to continue to contribute through research aimed at the development of new crop cultivars and products that could improve the productivity of new entrants to agriculture. This implies a need for investments in research to find solutions for existing problems in the sector. There is also the need for the ARC to provide and maintain a diagnostic and analytical service to manage (control) pests and diseases.

This production guideline gives tips and technical knowhow about the stages of growing vegetables, such as soil and climatic requirements, managing pests and diseases, harvesting, and so on.

The ARC remains committed to its quest to be a worldclass agricultural research organisation that consistently generates quality science and innovation in addressing the present and future challenges of our agricultural sector.

We wish to extend our appreciation to Farming SA for its support of this initiative.

Thank you!

Dr. Shadrack Moephuli, President and CEO, Agricultural Research Council
A demand for more vegetables
Vegetables form a vital part of the human diet because they are the source of many vitamins, minerals and proteins. In almost all developing countries, the consumption of vegetables is far from sufficient.

Vitamin A is one of the nutrients which is normally lacking in our diets and therefore dark-green leafy and orange vegetables should be consumed on a regular base.

The United Nations Food and Agricultural Organization (FAO) recommends an intake of 200g vegetables per person each day, or 73kg a year, to ensure adequate nutrient supply.

The farmer should practice correct cultivation (from the seedling stage), and sound management principles in order to produce healthy vegetable plants that are able to withstand various adverse field conditions.

When does production become profitable?
If, for example, onions are grown on 1ha of land, a yield of 4 000 bags of 10kg each of is possible. At R22 per 10 kg bag (R2.20/kg), this can provide a gross income of R88 000.

Input cost at present is R1/kg, so the profit is R1.20/kg. If the farmer is only paid R16 a bag, his profit is 60c/kg. If onions are grown on 10ha, however, and are successfully marketed, the income derived could be 10 times more. In other words, the smaller your farm, the smaller your profit will be. However, larger infrastructure must be available to increase production.

It’s essential to keep track of input costs: the price of fertiliser, for example, has increased by 200% during 2010 - 2011.

What to plant
It is important to make an informed choice when deciding which crops to grow. Producers should make sure that they know all that is required to grow a specific crop.

When planning production for the following growing season, therefore, the farmer should consider additional information for the various crops.
There is a need for fresh vegetables that can be marketed on a more commercial scale, but before deciding to do so, first consider the following:

- How far it is to the market.
- Whether the area to be farmed is suitable, in terms of climate and soil, for vegetable production.
- Sandy loam, and clay loam soils are best for the production of vegetables. Sandy soils can be problematic because of excessive drainage of water and nutrients as well as the presence of nematodes. This, in turn, can lead to stress of the crops and result in smaller yields.
- It is important to analyse the nutrient status of the soil regularly. Even more important than this is the quality of the water available on the farm. The Institute for Soil, Climate and Water (ISC W) at the Agricultural Research Council, is available to help you when it comes to soil and water analysis. (See contact list, page 44)
- After soil analysis has been done, the correct fertilisers have to be applied, in accurate quantities. This should ensure that the farm is run more economically. If the status of the soil is unknown, over-fertilising could cost a great deal of money.
- Poor quality water will affect soil quality — and the resulting crop — negatively. If a borehole is the only available water source and it doesn’t supply water at a rate of at least 1 litre/second, you cannot grow vegetables.
- The use of municipal water can be expensive for vegetable production, as the quantity of water needed to grow vegetables at an optimum yield can be very high; 15mm — 20mm of irrigation is needed once a week. Vegetables cultivated on 1 000m² (which is very small scale), require 15 000 litres (or 15kL to 20kL) a week; for a crop that grows for 90 days, that amounts to 192 000 — 262 000 litres (or 192 — 262 kL) per 1 000 m². To irrigate 1ha of land, 1 920 — 2 620kL litres of water will be required. For example, the cost per cubic litre of water ranges between R4,27 and R14,41 in Pretoria and R4,55 to R23,45 in Cape Town. The economics of the use of municipal water for irrigation should thus be determined beforehand.
- Infrastructure can either make or break a sustainable vegetable production unit. Transport is essential to obtain resources (on and off the farm) and tractors are needed to cultivate large tracts of land. Irrigation systems must be suited to the soil and crops produced, or the yield will be greatly reduced. The system must be manageable and well maintained. You will also need packing sheds or stores if a high-quality product is to be grown — and achieve a high price.
- Vegetable production is expensive with high input and labour costs and require optimum yield and quality to be produced profitably. Costs/financial resources are directly related to all of the above factors. If money is not available for all the inputs that you need for vegetable production, then abandon the idea.
## RSA sowing and planting chart for the most popular vegetable crops*

<table>
<thead>
<tr>
<th>Crop</th>
<th>Sowing time</th>
<th>Transplanting time</th>
<th>Harvesting time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes</td>
<td></td>
<td>Aug.</td>
<td>Nov.</td>
</tr>
<tr>
<td></td>
<td>Mar./Apr.</td>
<td>Thin out at a later stage</td>
<td>Jul./Aug./Sept.</td>
</tr>
<tr>
<td></td>
<td>Jan.</td>
<td></td>
<td>Apr.</td>
</tr>
<tr>
<td></td>
<td>Feb./Mar.</td>
<td></td>
<td>May/Jun.</td>
</tr>
<tr>
<td>Carrots</td>
<td>Feb.</td>
<td>Thin out 5 — 7 days after germination</td>
<td>May/Jun.</td>
</tr>
<tr>
<td>Sweet potatoes</td>
<td></td>
<td>Oct.</td>
<td>Feb./Mar.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nov.</td>
<td>Mar. — May</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>May — Aug.</td>
</tr>
<tr>
<td></td>
<td>Jan.</td>
<td></td>
<td>Apr./May</td>
</tr>
<tr>
<td>Lettuce</td>
<td>Feb.</td>
<td>Thin out 5 — 7 days after germination</td>
<td>May/Jun.</td>
</tr>
<tr>
<td></td>
<td>Nov.</td>
<td></td>
<td>Mar./Apr.</td>
</tr>
<tr>
<td></td>
<td>Dec.</td>
<td></td>
<td>Apr./May</td>
</tr>
</tbody>
</table>

*Please consult the seed company in your region regarding cultivars, which vary from area to area.
The huge variety of natural products now available is enough to confuse any farmer. Therefore we’ll give you some advice on what to consider when buying these products.

The increased demand for biological control products can largely be ascribed to problems developed from the use of chemical pesticides.

These problems include pest resurgence, resistance, environmental pollution and risks to human health. The biological control of plant pests and pathogens continues to inspire research, and there have been developments in many fields. Biological control is designed to reduce plant pathogens and limit pests such as insects, parasitic nematodes and weeds.

In the narrowest sense, bio-control involves the suppression of pest organisms by other organisms. However, the interrelationships of many environmental variables can result in multiple interactions among organisms and their environment, several of which might contribute to effective biological control.
Tough decisions

The rate at which biological control products or innoculants are being introduced into South Africa has increased rapidly since the early 1990s. Products may be single ingredients or blends of several materials. Some ingredients are recognized by the scientific and farming communities as having the ability to improve crop yields and/or quality. The value of others is often unknown and should first be evaluated for their ability to deliver upon the manufacturer’s claims.

Farmers more often than not, find themselves in a situation where they need to make decisions about purchasing such products.

The following guidelines can help farmers make informed decisions:

- Be aware of the specific disease problems you experience on your farm. Biological products can be very specific with regard to disease control.
- Find out if the proposed product has been registered, in terms of Act 36 of 1947.
- Look for a label on the packaging that contains specific information about the product, such as shelf life, application rate, active organisms and compatibility with other biological control products.
- Find out at what pH and temperature range the biological agent is active. This information is very useful for the effective storing and application of these products.
- Find out if the biological control product is compatible with the chemicals you apply during a growing season. Biological products contain living organisms that can be deactivated or killed by agrochemicals.
- Can the company selling the product provide you with a professional consulting service for setting up an Integrated Pest Management control programme before selling the biological control products? This should include a thorough investigation of the disease problem situation on your farm and current crop management practices.
- Does the company provide detailed instructions on how to handle and apply biological control products?
- Is there any measure of the quality and purity of the biological control product you received? For example: Does the company tell you exactly which organisms are contained in the product and who made the species determination?

This should have been done by a recognised taxonomic expert, not necessarily someone at the company. Does the company offer reasonable solutions for any difficulties you may encounter and does it follow up to determine the success or failure of your programme?

Instead of jumping right in to using the product on your entire farm, first test it to see whether it actually yields results in your production environment.
Swiss chard diseases include: Cercospora leaf spot, which causes small dark, brown spots on the leaves, the spots are lighter coloured in the centre and Pythium root rot which causes root to rot if the soil is too wet. Monoculture production has been associated with an increase in pests and soil-borne disease. Using crop rotation and companion planting can help to break disease cycles and improve soil health.

Crop rotation is one of the most basic principles of vegetable production and should always be practised. It’s best described as a system of crop production in which various crops are grown in such a way that no crop is planted on the same piece of land more than once in three planting cycles (but preferably four).

While crop rotation is recommended for improving soils and for conservation purposes, its greatest benefit lies in the reduction of disease levels in the soil. Many pathogens can persist in the soil after the crop has been removed (such as black-rot in cabbage).

Failure to practise crop rotation will result in an increased rate of infestation, in turn leading to higher pest management costs. Crop rotation might also reduce unwanted insect populations and perennial weed infestations. An example of a crop rotation system using five plots, over five growing cycles, is given in the table.

**Table: An example of a crop rotation system.**

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Plot 1</th>
<th>Plot 2</th>
<th>Plot 3</th>
<th>Plot 4</th>
<th>Plot 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Leafy crops</td>
<td>Legumes</td>
<td>Brassicas</td>
<td>Root crops</td>
<td>Solanaceae</td>
</tr>
<tr>
<td>2</td>
<td>Solanaceae</td>
<td>Leafy crops</td>
<td>Legumes</td>
<td>Brassicas</td>
<td>Root crops</td>
</tr>
<tr>
<td>3</td>
<td>Root crops</td>
<td>Solanaceae</td>
<td>Leafy crops</td>
<td>Legumes</td>
<td>Brassicas</td>
</tr>
<tr>
<td>4</td>
<td>Brassicas</td>
<td>Root crops</td>
<td>Solanaceae</td>
<td>Leafy crops</td>
<td>Legumes</td>
</tr>
<tr>
<td>5</td>
<td>Legumes</td>
<td>Brassicas</td>
<td>Root crops</td>
<td>Solanaceae</td>
<td>Leafy crops</td>
</tr>
</tbody>
</table>
The crops planted include:

**Legumes:** Beans, peas, cowpeas, pigeon peas and bambara.

**Brassicas:** Cabbage, Chinese cabbage, kale, radishes and cauliflower.

**Root crops:** Carrots, beet, sweet potato, amadumbi and onions.

**Solanaceae:** Tomatoes, peppers and potatoes.

**Leafy crops:** Swiss chard, amaranthus and cleome.

**Cucurbits:** Pumpkins, squash, melons and cucumbers.

**Green mealies and cucurbits** can be included in the rotation at any point.

Another general rule is not to plant an underground bearing crop in consecutive seasons in the same soil.

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**Staggered planting**

A continuous supply of vegetables can be achieved by staggered planting: making smaller, plantings at regular intervals (for example every four weeks) during the planting season to ensure a continuous supply of the crop.

Maturity can be predicted in part by using days from planting to harvest for each crop. Continuity can also be achieved to some extent from single plantings of crops which don’t require a certain stage of maturity to be ready for harvesting, such as sweet potatoes which can be harvested when the size is adequate for marketing.

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**Companion planting**

Companion planting also has value to protect plants from pests. It’s based on the theory that the companion plants — for example, flowers growing next to a food crop — disrupt the search pattern of pests looking for host plants.

They detect the host plants but become confused because of the more diverse planting style.

Separating rows of cabbages, broccoli or other brassicas with rows of onions is a popular combination, and possibly works because the onion’s strong smell disrupts cabbage pests.

Tomato plants grow well next to cabbages, which seem to deter caterpillars. Growing leeks near carrots seem to repel carrot flies. Planting marigold or calendula between vegetables may reduce unwanted nematodes in the soil.

Nematodes occur naturally in the soil, but monoculture can result in a build up of species that could be harmful to specific crops. These nematodes might feed on the root system of host plants and can cause considerable damage.

A variety of herbal plants planted amongst the vegetables or around the vegetable patch may have beneficial effects. Basil planted with tomatoes and lettuce may deter insects. Oregano planted with broccoli may repel cabbage flies.
The tomato

a versatile, popular and vulnerable crop
Tomatoes are among the most popular crops cultivated throughout the world. Unfortunately, the crop is susceptible to numerous pests and diseases. Here we look at control measures. Several hundred varieties of tomatoes are grown throughout the world, and in recent years there has been a lot of research into producing new cultivars and hybrids for specific purposes. Tomatoes can be eaten raw in salads or cooked, fried or sundried. Popular processed products include jam, chutney, tomato sauce, canned tomatoes, and sundried tomatoes. They are a good source of vitamins A and C and essential minerals. Tomatoes come second, after potatoes, in the quantities produced in South Africa.

The following types of tomatoes are available in the country:
- Fresh market cultivars.
- Processing/canning cultivars.
- Dual purpose cultivars.
- Cherry tomatoes.

**Fertilisation**

Soil samples should be taken at least every three years, usually a few months before planting, in order to rectify any soil fertility problems. There should be an adequate supplementing of potassium (K) in soils that lack it, to improve fruit solidity. If it isn’t possible to do soil tests (on a small scale), follow these general guidelines:

- Apply a dressing of approximately 1 000kg per hectare (100g/m2) of a fertilizer mixture such as 2:3:4 (30) +Zn and mix it into the top 10cm of the soil. Do this a week or two before planting. Otherwise 30m3 compost or kraal manure can be used per hectare.
- Tomato plants respond well to a top or side dressing of 50kg/ha (5g/m2) 1:0:1 (36) and 50kg/ha (5g/m2) LAN (28), alternated every three weeks after transplanting until week 18, provided the plants are still growing and healthy. It is good practice to weed the crop first before applying a top or side dressing.

Fertiliser should be placed at the base of each plant (5 — 10cm away). Then water the plants well after fertilising.

**Irrigation**

The frequency of watering depends on the soil type and temperature. It is best not to use an overhead sprinkler irrigation system because wet leaves encourage early and late blight.

It is important to supply sufficient water at critical times, such as immediately after sowing or transplanting. It is also important that young plants get enough water for vegetative growth before flowering.

To ensure good crop quality, look out for wilting leaves in the late morning and if there’s any sign of this, water the plants in the afternoon as well.

During the first four weeks, 21mm of water per week is needed; for the following eight weeks 38mm/week, and for the remainder of the growing season, 31mm/week. Too much water after the fruit has formed, can cause them to crack. About 500mm of water is required throughout the entire growing season.

**Staking**

Fix a stake into the ground next to each tomato plant, and tie the stem loosely to it to prevent its collapsing. You can also use a trellis instead of individual stakes, but you will still need a sturdy stake fixed into the ground every 4m along the row. Staking stops the fruit touching the ground, thus limiting the possibility of diseases infecting the fruit or leaves.

The practice is sometimes a controversial subject among commercial growers, because of the labour and expense involved. Cultivars for processing are usually not staked; indeterminate (strong-growing) cultivars often are. If only a few rows have been planted or space is limited, e.g. in home gardens, staking is recommended for both types of cultivar.
Pests and diseases

The most important pests on tomatoes are root-knot nematodes, cutworms, bollworms, army worms, leaf miners, thrips, red spider mites, and aphids.

**Cutworms** are often troublesome in the seedbed and a threat to newly transplanted tomatoes. They are the greyish hairless caterpillars produced by a moth. At night the caterpillar cuts the seedling/plant just above the ground, severing it from its roots. Cutworms are usually found near one of the damaged plants 2 — 5cm below the soil surface. Keeping fields free of weeds is the best way to reduce cutworm numbers before planting. Start weed control six weeks before sowing or transplanting.

**Caterpillars** The larvae of night flying moths (caterpillars) are often found feeding on tomato plants and fruit. Most of them attack several crops. The moths usually fly in from the surrounding area at night. Examples include bollworms (see page 24), loopers, semi-loopers, lesser armyworm and Spodaptera larvae. Numerous insecticides are registered to combat loopers. If there are few caterpillars, they can be removed by hand.

**Tomato rust mites** are about 0.2mm long. They feed on stems and leaves. The first signs of damage are the lower leaves curling up. The infected leaves look bronzed. Later these leaves wither and eventually die.

**Red spider mites** are tiny (less than 1mm), red-brown, wingless arthropods (not insects). They penetrate plant cells and suck up the chlorophyll (which gives the green colour to leaves). They stay under the leaves but in a severe infestation they appear over the whole plant. Fine webbing is visible between leaves when infestations are severe, and the leaves turn light yellow. Infected plants may die and those that survive will produce very little fruit. Red spider mites prefer dry, hot conditions. There are various insecticides to control mites on tomatoes.

**Whiteflies** are small, white, sucking insects that can be seen flying around the plant when the leaves are disturbed. The wings and bodies of the adults are covered with a fine white powder. They gather in large numbers under the leaves, sucking the sap of plants. White flies can also introduce harmful viruses into a field. Nymphs (immature whiteflies) are also found under the leaves and are greenish to translucent in colour. Insecticides can control them. Protect seedlings with a mesh cover.

**Liriomyza leafminers** are larvae (maggots) of a small (2mm) fly, which has a distinctive yellow dot between its wings. The female fly makes small puncture marks on the leaves where she lays her eggs. The larvae create long, thin tunnels while feeding inside the leaves. Heavy infestation damages the foliage to such an extent that it reduces fruit set and also results in sunburn to ripening fruit.
**Aphids**

Aphids are insects (1.5 — 2.5mm) ranging in colour from green to black. They prefer to hide under the leaves or congregate near the growth points of a host plant. Aphids usually reproduce without mating and under favourable conditions don’t lay eggs but bear their young live. They don’t usually have wings but when they increase in numbers and during unfavourable conditions, some do develop wings. Aphids suck up the plant’s sap, but the most significant damage caused by these insects occurs when they transmit plant viruses.

**Bollworms** are the offspring of a night-flying moth which varies in colour from dull yellow to brown. These moths lay yellowish-white eggs and their pupae are formed under the soil. The fully-grown larvae are about 30 — 40mm long. Young bollworm caterpillars’ bodies are hairy and their colours vary from black to brownbeige. Bollworm larvae feed on flowers, leaves and the fruit of tomatoes. Later they may feed inside a hollowed-out fruit. As with any insect damage, secondary diseases may also occur later. Nearly 30 insecticides are registered against bollworm on tomatoes. When their numbers are low, removing them by hand may be an option.

**Potato tuber moth larvae** are tiny, light coloured caterpillars which bore into both unripe and ripe tomatoes, starting at the point where the stem is attached to the fruit. This causes the fruit to rot. A tiny black ring usually indicates the entry point. It is not easy to notice the damage in its early stages. Tuber moth larvae also tunnel into leaves, leaving “windows”.

The infected fruit is unmarketable. Infected fields must be destroyed by burning after harvest. Never try to plant new tomato crops in or near old plots. Insecticides can control tuber moth larvae in tomatoes.

**Nematodes** are microscopic worms (not insects) living in the soil. They induce large lumps or galls on a plant’s roots. Yields will be low, plants may be stunted and wilting of the top growth may occur. The best management technique is to use newer, tolerant cultivars and follow the suggested rotation with other crops.

Growing marigolds (Tagetes spp.) reduces nematode numbers in infested soil within one season, but a single replanting of tomatoes on the same field may build up the nematode numbers to unacceptable levels. Several nematicides are registered for nematode control on tomatoes. You could also avoid nematode-infected fields by practise fallow ploughing.

**Cultivar list**

Fresh market: Zeal, Score, Checha, STAR9003, Disco, Bravo, Stormer, Settler, Sundance, Rodade, Flora-Dade, otam-4. Processing: UC82B, Kamatla, Qwanto, Roma VFN.
In this article, we focus on the fungal infections every tomato producer should guard against. In wet weather it is advisable to place a handful of grass under any fruit that is in direct contact with the soil. Pruning tomato plants is not recommended as this usually results in a lower yield and more cracked fruit.

Remove some leaves
For indeterminate (strong growing) cultivars that are drip irrigated, it’s good practice to remove the leaves from the main stem when the first cluster of tomatoes starts showing colour.

If the leaves under the cluster are removed, greater circulation of air between plants will help prevent fungal infection. The most serious diseases found on tomatoes are bacterial canker, bacterial wilt, black stem, *Fusarium wilt*, *Verticillium wilt*, early blight, late blight, powdery mildew, *Botrytis* rot, tomato spotted wilt virus, tobacco mosaic virus and tomato yellow leaf curl virus.
Bacterial diseases

**Bacterial canker:** This common disease can be devastating in both field and greenhouse plants. Plants show progressive wilting, and older leaves die (but remain attached to the plant). There is browning around the leaf edges and in the internal stem tissues. Bacterial canker is primarily spread through infected seed and seedlings. Systemically infected seedlings show no disease symptoms, which makes detection of the disease difficult in nurseries.

**Control**
Plant disease-free seedlings; use resistant cultivars; apply strict sanitation in and around plantings; and practise crop rotation.

**Bacterial wilt:** This disease can be a serious problem in warm sub-tropical areas such as South Africa’s Mpumalanga and KwaZulu-Natal provinces. Initially young leaves show wilting, after which plants wilt quickly and die. There is no browning or yellowing of leaves or stems. If the lower stem of a badly wilted plant is cut across and placed in water, a white milky stream of bacteria flowing out of the cut end is often visible within a few minutes. Stems show a mild internal browning of tissues when cut open lengthways. Bacterial wilt attacks a wide range of plants, some of which are economically important crops. It is spread by infected seedlings, infected water and the movement of infected soil and ground water to healthy production areas.

**Control**
Plant disease-free seedlings; plant resistant cultivars; apply strict sanitation practices; implement crop rotation; control weeds and nematodes; and avoid over-irrigation.

**Black stem.** Bacterial speck and black stem are both caused by the same bacterial pathogen P. syringae pv tomato. Bacterial speck is common, occurring as small brown spots on leaves, stems and fruit. Leaves could die, and infected fruit is downgraded. Nursery plants are often the primary source of infection. Bacterial speck is frequently found with bacterial spot.

Black stem causes a blackening of stems and leaf stalks. Although the blackening is fairly superficial, the plant is harmed. This disease is primarily a problem of tomatoes under protection and seldom occurs in the field. High humidity in greenhouses/ tunnels is conducive to the spreading of this disease.

**Control**
Practise crop rotation; implement strict sanitation practices; avoid over-irrigation; reduce humidity in the greenhouse/tunnel; plant disease-free seedlings; and apply chemical control.
Fungal diseases

**Early blight:** This widespread disease occurs in humid, moderately hot, or in semi-arid, areas that regularly experience dew. The pathogen attacks leaves, stems and fruit. Lesions start as small brown spots on older leaves and stems, and grow rapidly into large brown/black spots with concentric rings that are often visible in the lesion. The fruit is attacked at the stem end where water accumulates. Leaf and fruit drop usually result.

![Early blight](image)

**Control:** Plant resistant cultivars; use only disease-free seedlings; apply chemical control; eradicate weeds and volunteer tomato plants; provide a well-balanced fertilization programme; do not use an overhead irrigation system; and apply crop sanitation.

**Late blight:** This disease is also common and can be very destructive under prolonged wet, cool conditions. All parts of the plant above the ground can be attacked. Leaves initially show light green blighted areas, which quickly turn black, with a whitish/grey fungal growth often visible underneath the lesions when conditions are very humid. Stems show extensive black lesions. Leaves and stems are quickly killed during the spreading of the pathogen. Infected fruit show diffuse blackening with a greasy appearance and deteriorate rapidly. Under optimal conditions, late blight can cause total crop loss within a week.

**Control:** Apply chemical control; do not use overhead irrigation systems; and maintain crop sanitation practices.

Powdery mildew. This widespread disease is a serious problem in hotter areas such as South Africa's Mpumalanga and Limpopo provinces. The disease favours hot periods when humidity is low. Initially, pale green/yellow spots with a diffuse margin occur on the upper leaf surface. Later spots enlarge and develop into large necrotic (brown) lesions. If lesions are viewed from below (under the leaf), a whitish fungal growth is sometimes just visible. Badly infected leaves die, but seldom drop, and fruit gets sunburnt. Plants grown under drip irrigation are more susceptible to powdery mildew than plants under overhead irrigation.

**Control:** Apply chemical control, weed control and crop rotation with non-susceptible crops.

**Blossom end rot:** Hard brown spots occur on the tomato’s blossom end.

**Control:** Mulching; avoiding root pruning; regular irrigation; calcium fertilisation (calcium nitrate, gypsum and lime); and avoiding high nitrogen fertilisation.
Viral diseases

Potato virus Y (PVY)
In South Africa, PVY is mainly a problem in Mpumalanga’s Lowveld region. PVY also attacks potato and pepper plants. Infected leaves initially show yellow or transparent veins, later developing a mosaic pattern and sometimes necrotic (brown) spots. Occasionally, infected plants are symptomless. PVY is spread by aphids. This makes a preventative control programme of aphids essential.

Control: Control aphids chemically; avoid planting near other susceptible crops; plant resistant cultivars; and practise crop sanitation and weed control.

Grey mould
Grey mould is found in all South Africa’s tomato-producing areas and leads to fruit rot. It could be a problem when tomatoes are grown at moderate temperatures and under high humidity or prolonged leaf wetness (dew). All above-ground parts of the plant could be attacked.

The pathogen invades the plant through wounds (e.g. pruning wounds, growth cracks), or through dead/dying tissue (old flowers, dead leaves). Light brown lesions are formed, and the fungus is often clearly visible as a grey/brown growth within the lesion.

The disease occurs in both field and greenhouse tomatoes, but is more common in greenhouses where high humidity frequently occurs.

Control: In the case of greenhouse tomatoes, reduce humidity levels by venting; remove infected plants/plant debris from the production area; and optimise ventilation between plants.

In the case of field tomatoes, plough in crop residues. And in the case of greenhouse and field tomatoes, apply chemical control.

Tomato spotted wilt virus (TSWV)
TSWV is widespread in South Africa and occurs on various host plants. It attacks tomatoes in all areas. It is a serious problem in the Western Cape and in the Eastern Cape.

Young leaves curl downwards and can show rings; older leaves are bronzed or show a mosaic pattern.

Stems and leaves may show a necrotic (browning) pattern, and infected fruit display characteristic concentric rings. Infected plants are stunted. TSWV is spread primarily by the western flower thrips and the onion thrips.

The larval stage of the thrips acquires the virus when feeding on the plant, but the virus is transmitted to healthy plants during feeding by the adult thrips. TSWV is not transmitted by seed.

Control: Apply chemicals; plant resistant varieties; apply crop sanitation; weed control.

Tobacco mosaic virus (TMV)
TMV is widespread in South Africa. First reported on tobacco, TMV attacks a wide range of host plants.

Leaves show abnormal growth (malformation, stunting) and a green or yellow mosaic pattern. Necrosis (browning) occurs on leaves, stems and fruit. Fruit ripens unevenly, is small and shows browning of the fruit wall when sliced open. TMV is spread mechanically. Examples of how it can be spread are by tobacco products, workers (hands, clothes), implements or infected water.

TMV is transmitted by seed, pollen or roots.

Control: Apply strict sanitation in the production area; plant resistant cultivars; control weeds; and ban the use of tobacco products in and around plantings.
Swiss chard — which is far more common in this country than swiss chard — is easy to grow and packed with nutrients too. Swiss chard looks very similar to swiss chard but has much broader leaves, thick stems and contains more vitamin A. True spinach is richer in calcium (Ca) than Swiss chard, but it is in an oxalate form and is not healthy for children. Because of this, and swiss chard low yield, Swiss chard has become widely cultivated in South Africa. It belongs to the beetroot family and is grown annually for its nutritious, luscious leaves. Both leaf and stem (petiole) are edible and can be cooked separately.

In addition to vitamins, Swiss chard also contains considerable quantities of readily available minerals of which iron is the most important. The crop is relatively easy to cultivate and can be harvested regularly. Average yields range from eight to 10t/ha, to a maximum of 15t/ha.

**Soil and climate requirements**

Swiss chard requires fertile, welldrained soil. A sandy loam soil is the best, but it also does well in loamy to clay soil with a pH of 6 to 6.8. Although it is a cool weather crop, it can also be grown in the hot summer months. This can, however, result in bolting (seeding) in some cultivars. Optimal temperatures range between 16°C and 24°C. The best time to plant it on the Highveld is from August to March; Middleveld from August to April; and Lowveld, March to June.

**Crop rotation and soil preparation**

Do not plant the crop on the same land every year, because this can lead to the build-up of pests and diseases in the soil. Rotate the crop with other vegetables such as pumpkin, beans, peas, lettuce, tomatoes, potatoes and cabbage. As is the case for the production of other vegetables, it is important to clear the planting area of weeds and grasses at least a month in advance. You can use a fork to turn and loosen the soil. Doing this can help prevent pests and diseases from infecting new crops. The soil must be watered well before preparation. This will ensure that the soil is not compacted, which will enhance drainage, root penetration and aeration. Loosen the soil with a plough or fork. Swiss chard requires a lot of compost or manure, in addition to fertiliser. The seedbed must be well prepared for direct sowing and have a very fine structure. Big clods of earth will prevent germination.
**Planting method and spacing**

Seedlings can be planted 10 — 20cm apart, and in rows 25 — 35cm apart. Seeds can also be sown directly in shallow rows or furrows. Use a spade or rake to make furrows 2 — 3cm deep. Sow seeds 2cm apart and cover with soil, smoothing with a spade or rake. Water the soil directly after sowing and cover with a thin layer of grass (mulch) if it’s hot. Keep the soil damp. Plants will germinate in seven to eight days. Remove the grass mulch after five to six days to avoid long, leggy seedlings. These plants are top heavy and can easily be damaged by the sun. It is important to thin seedlings out to 10cm apart, not later than three weeks after the seedlings have emerged.

**Fertilising**

Use 2:3:2 (22) Zn as fertilizer before planting. Apply 900kg/ha or 90g/m2 and mix it into the top 10cm of soil. Apply top dressing three weeks after transplanting or emergence, at a rate of 16g KAN/LAN per 1m row. Apply in the area 5 — 15cm away from the plants on both sides. This means that 8g of LAN is applied per 1m row on each side of the plant. Top dressing is very important, because swiss chard needs a lot of nitrogen to produce good-quality, broad leaves and therefore good yields. A second top dressing is required eight weeks after emergence or transplanting, especially in lighter soils. Be careful not to apply the KAN/LAN fertiliser directly onto the plants, because this will burn them. When the fertiliser has been applied, mix it into the top 2cm of soil, using a fork. Do not damage the shallow roots, especially in the early stages of growth. Water the plants immediately after fertilising.

**Water requirements**

Because swiss chard has a very shallow root system, the soil must be kept moist throughout the growing season. In fact, the crop requires an irrigation cycle as frequent as once or twice per week.

**Harvesting and storage**

The crop must be harvested regularly to stimulate regrowth and a higher yield that won’t bolt easily. Only the outer leaves should be removed, using a sharp knife, 30 — 50mm above the soil. Be careful not to damage new shoots. If the leaves are not used immediately, they can be bunched and placed in water to keep them fresh for longer. Because of the high transpiration rate of the broad leaves, the keeping quality is poor. If you are able to store the swiss chard in a refrigerator, it can be kept for 6 — 8 days.

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**HOW TO STRETCH THE SEASON FOR SWISS CHARD**

Swiss Chard belongs to the beetroot family and is grown for its nutritious, luscious leaves. Swiss Chard is a good source of folate and vitamin A. Vitamin A is required for normal functioning of the immune system and for eye health and vision.

Vitamin A deficient children have a lower resistance against common childhood infections such as respiratory and diarrhoeal diseases, measles and malaria. Except for vitamins, it also contains considerable amounts of readily available minerals of which iron is the most important. Uptake of iron by humans is enhanced by adding tomato (vitamin C) during cooking.
This calls for increased spinach production, not only in home gardens, but also at schools and health centres. The crop can be grown for a large part of the year and allows for a constant supply to enable the home gardener to spend less money on buying vegetables.

Under normal conditions, a spinach plant would be grown for just under five months, then new plants would be sown if necessary. Spinach can be grown using low inputs and gives sizeable yields on limited space. Some home gardeners have also learnt to stretch the spinach growing season. How successful this is will depend on the area and climatic conditions. The crop can stay in the field for more than seven months, provided there are no adverse weather conditions, such as hail.

It became clear in 2007, during a research trial by ARC Roodeplaat, that cumulative yields of the spinach cultivar Ford Hook Giant can be increased by a prolonged growth season. Yields of up to 50t/ha were achieved using compost as a plant nutrient. Compost suits low-input or resource-poor farming. Yields can be further increased by adding chicken manure.

This is because chicken manure has a high content of nitrogen which is a major element needed for enhancing the yield of leafy crops. Increased yields of up to 70t/ha were observed when a top dressing of inorganic nitrogen had been applied.

**Prolonged production and palatability**

Younger spinach plants are more palatable and often have a higher concentration of healthy vitamins. Many green, leafy vegetables and root crops having high succulence (crisp, high moisture content) respond well to nitrogen fertilising. It is essential that these vegetables have an abundant supply of nitrogen to maintain their green colour and succulence. Nitrogen deficiency in spinach and radishes is apparent from restricted shoot and root growth and yellowing of the leaves. The nutritional value and palatability of spinach decrease with nitrogen deficiency.

On the other hand, too much nitrogen applied to spinach may lead to excessive nitrate accumulation in the plants. This is not unique to spinach and radishes but sometimes occurs in other vegetables. Nitrates in vegetables may be a hazard to human health under certain conditions.

*Swiss chard at different growth stages. Young leaves are more palatable but the yield will be lower*
Pests & diseases

Swiss Chard diseases include:
**Cercospora leaf spot**, which causes small, dark brown spots on the leaves; the spots are lighter coloured in the centre.

**Pythium root rot**, which causes roots to rot if the soil is too wet.

There are no registered chemicals for disease control in spinach. Avoid over irrigation and follow general disease control measures:
- Practise crop rotation.
- Remove infected plants and burn or bury them.
- Remove all plant residues after harvesting.
- Fertilise plants well.
- Avoid over-watering.
- Water plants early in the day, so that leaves can dry before nightfall.

Spinach diseases include:
**Cercospora leaf spot**, which causes small, dark brown spots on the leaves; the spots are lighter coloured in the centre.

**Larger insects**, which make large holes in the leaves can cause a lot of damage.

**Control**: Check regularly. Spray chemicals registered for aphids.

**Nematode infestation**, which can be seen as swellings on the roots.
**Control**: Crop rotation. Intercropping with marigold, mustard and rapeseed; fallowing; soil solarisation. Registered pesticides are Nemacur and EDB.

**Cutworm**, which normally hibernate under the ground during the day and come out at night to feed on the small seedlings.
**Control**: Check regularly. Use cutworm bait.

**Red spider mite**, An early sign of infestation is stippled areas on leaves. Leaves become chlorotic and in severe cases webs are produced on leaves and stems.
**Control**: Check regularly. Spray with Sunlight liquid diluted in water.

Important pests:
**Aphids** suck plant juices and transmit viral diseases.
**Control**: Check regularly. Spray with soapy water (Sunlight liquid diluted in water).
Registered pesticides are Phosdrin and Mevinphos.
How to produce, harvest and store

**Sweet Potatoes**

Sweet potatoes form a key staple and poverty-relief crop in southern Africa. Orange-fleshed types are useful in combating the vitamin A deficiency which causes many African children to go blind.

The sweet potato performs well in sandy-loam, loam or clay-loam soil. It needs good drainage and is sensitive to water-logging, salinity and alkalinity. Stony or clay soils are not suitable for developing good storage roots. The optimum pH of irrigation water should be 5.6 — 6.5.

**Required climate**
As a warm season crop, sweet potato is sensitive to low temperatures, especially frost. It performs best in subtropical areas but can be grown in all South African provinces, provided supplementary irrigation is available. The plant develops a degree of drought tolerance after the storage roots have formed.

**Crop rotation**
Crop rotation is essential to prevent disease and pest build-up. Sweet potatoes should only be cultivated in the same soil once in three years.

**Propagation**
Propagation is by stem cuttings. Always cut shoots from a healthy plant. Do not use vines from volunteer sweet potatoes because these might carry pests and diseases. Pieces of stem 20 — 30cm long should be taken for cuttings. The leaves can be removed from the cuttings before planting, but this is not necessary.

Top cuttings are more vigorous than cuttings from other parts of the vine. Plant them in a prepared bed by covering half their length in moist soil.

Press surrounding soil down firmly so that it makes proper contact with the stem to promote quick root development. Water the plants immediately after planting.

**Cultivar list**

- Orange-fleshed: Bophelo, Impilo
- Cream-fleshed: Ndou, Monate (dry test), Bosbok (moist)
Soil preparation
Loosen the soil to a depth of 25 — 30cm to allow for good root aeration, root penetration and drainage by either ploughing or using a fork, hoe or spade. Remove stones and break down hard soil layers. All clods should be smashed until a deep, fine bed is obtained.

Planting method
Ridging. Sweet potato plants are grown on ridges or mounds. The ridges are especially beneficial in areas prone to flooding and also ease harvesting. Cuttings are laid 30cm apart on the ridge, with the basal end planted in the soil. Holes of suitable size are made, the vines placed in the holes and soil pressed down firmly around the cutting. Cuttings are planted vertically with 3 — 4 buds (nodes) under the soil surface.
Flat bed. Some farmers grow sweet potatoes on flat beds in sandy soil with good results.

Spacing
Sweet potatoes can be regarded as a field crop rather than a home garden vegetable. This is because its runners take up a large area. For the home garden (where space is limited) a row or two should do. Place stem cuttings 25 — 35cm apart (or the length of a spade blade) in the row. Generally, ridges of 1m apart are used, but they can also be 90 — 150cm apart for field production or 80 — 90cm for home gardens, and about 30 — 40cm high.

Planting time
**Areas with light, mild frost:** beginning of November to mid-December.
**Areas with heavy frost:** mid-November to beginning of December.
**Frost-free areas:** August to March.
**Cooler areas:** September to February.
**Winter rainfall areas:** mid-November to beginning of December; November is optimal.
Fertilisation
Soil samples should be taken a few months before planting in order to rectify soil fertility problems. General recommendations are the following:

- Sweet potatoes need a high ration of nitrogen (N) and potassium (K). Approximately 500 — 750kg/ha (75g/m²) of a fertiliser mixture such as 2:3:4 (30) + 0,5% Zn or 2:3:2 (22) + 0,5% Zn, or 3:2:1 (25) + 0,5% Zn can be applied directly before planting. It must be worked into the soil lightly before making the ridges. For sandy soils the quantity can be increased to 1 000kg/ha. Apply a top dressing of 120 — 150kg/ha LAN (12g/m of row) or 200kg/ha (20g/m²) ammonium sulphate three weeks and six weeks after planting, if necessary. Sandy soil will require at least two top dressings. Water well after the fertiliser has been applied.
- Well-matured (six months) compost may be used to supplement part of the chemical fertiliser, but it must be worked into the soil some time before planting.

Water requirements
Sweet potatoes are moderately drought tolerant. Water stress during the first few weeks after planting and the period of tuber formation (30 — 60 days after planting) will cause low yields. As a general guideline, sweet potatoes require between 450mm and 600mm of water, well distributed throughout the growing season.

Harvesting
The sweet potatoes are ready for harvesting four months (warm areas) to five months (moderate areas) after planting. Soil should be soft during harvest to prevent breakage and skin damage. Withhold watering from about 30 days before harvesting as a way of field curing. In warm areas, cut vines four to seven days before harvesting for the tubers to cure.

Use a hand fork to lift the tubers and take them out by hand. Make sure you do not damage them. If too long a season is allowed, the tubers will become too large. Rub the soil from the sweet potatoes, wash and leave them to dry in sun for one to two hours when temperatures are moderately high. At 32°C, harvested tubers can get sun scald within 30 minutes. If left on the field at night at temperatures below 5°C, chilling injury will occur. Store the tubers in a cool, dry place at about 15°C.

Storage
Sweet potatoes can be stored fresh for three to six weeks after harvesting. Do not store damaged tubers. They can also be left in the ground until such time as they are needed. It is better to extend harvesting through planting at fortnightly intervals during the planting season.

Sweet potatoes can be used in many different ways

- Storage roots can be eaten raw, boiled, baked or cooked.
- The tips of shoots (petioles) and young leaves serve as a vegetable. Crop residues are useful as stock feed.
- Storage roots can make starch, alcohol, flour, jam, and juice.
- The high carbohydrate content makes sweet potatoes a key energy source.
- The orange-fleshed sweet potato is a good source of vitamin A.
- Green leaves provide additional protein, vitamins and minerals.
Protect your harvest

Sweet potato is less affected by diseases and pests than most crops. Sweet potato weevil and sweet potato moth are the pests that most often affect sweet potatoes. The most important field diseases are sweet potato feathery mottle virus, fusarium wilt, alternaria leaf spot, and scurf. During storage soft rot, surface rot and dry rot may occur.

Sweet potato weevil
Adult weevils feed on foliage. The larvae tunnel into the sweet potato tubers and stems. Preventive measures include the following:

- Crop rotation, which can help reduce the weevil population.
- Earthing-up tubers, which generally reduces infestation.
- Removing all tubers at harvest and never using cuttings from volunteers; in other words, from plants emerging in a field where sweet potatoes were planted the previous season.
- Burning all infested plants after harvesting.
- Using plant cuttings which are free from weevils or larvae.
- Not planting cuttings close to the previous sweet potato crop.
- Reducing soil cracking.
- Adjusting planting times so that there are no tubers in the dry season.
- Harvesting at the right time, as in-ground storage during the dry season promotes damage.
- Spraying with registered chemicals.

Larvae of sweet potato hawk moth
Large brown larvae (worms) which have a horn on the back of their bodies, feed on the leaves of sweet potatoes. Control them with registered chemicals at an early stage. Hand-picking larvae is usually sufficient if numbers are not too high.
**Field diseases**

**Fusarium wilt** can cause severe yield loss. When cutting through the stem of an infected plant, a reddish-brown discolouration of vascular tissues can be seen. The leaves and stem turn yellow, wilt and die. Infected plants also infect the soil.

Preventive measures include the following:
- Using wilt-resistant cultivars.
- Using disease-free planting material.
- Practising field sanitation.
- Removing infected and old plant residues.
- Rotating crops.
- Limiting any stress such as water deficiency combined with high temperatures during the growing season.

The same measures apply to alternaria leaf spot and scurf.

**Sweet potato feathery mottle virus**

Although symptoms are seldom seen on the leaves, the yield decreases severely and there are more cracked tubers.

*Here are some preventive measures:*
- **Planting virus-free material** — obtain cuttings from registered vine growers or from ARC - Roodeplaat.
- **Controlling weeds in and around the field,** especially wild ipomoea species.
- **Using healthy-looking, vigorous material.**
- **Removing volunteer sweet potato plants,** debris and weeds from the previous season before planting.
- **Renewing plant material every two to three years.**
- **Cleaning all cutting equipment with a strong bleach solution.**

**Storage diseases**

Try the following preventive measures against storage diseases such as soft rot, surface rot and dry rot:
- Do not store damaged sweet potatoes and those showing signs of disease.
- Remove and destroy infected tubers from the storing place.
- Store them in a cool, dry place.
- Clean containers with bleach.
Pumpkins, squash, calabash, marrow (Cucurbita sp.), watermelons, cucumbers (Cucumis sp.) and muskmelons are members of the family Cucurbitaceae also called cucurbits. Pumpkins and squash contain potassium and beta-carotene (the precursor of vitamin A), and the seeds are rich in zinc. It is used to make soups, pies and breads, used as feed for animals and even their flowers are edible. Like other members of the family, the flowers of pumpkins and squashes are mostly unisexual and the plants monoecious (male and female flowers are separated but are borne on the same plant). Pumpkins range in size from less than a 0.45g to over 454 kg. Cucurbits that are round and orange are called pumpkins, while those that are other shapes and colors are called squash.

Soil
The best results are obtained on loamy to sandy loam soils. Heavy soils that do not drain readily should be avoided to prevent fruit rot. Soil should be slightly acidic, but good results can be obtained over a wide range of pH (H2O) values extending from 6.0 to 7.5. If the soil is more acidic than pH (H2O) 5.5 agricultural lime should be applied in accordance with the soil analysis results. The ideal soil depth is 40 cm.

Climate
All cucurbits are warm-season crops. Cucurbit seeds do not germinate in cold soil, and the seedlings are injured by frost. Cucurbits grow best at temperatures of 23-29ºC (day) and 15-21ºC (night). Growth virtually stops at temperatures below 10ºC and the plants may be severely injured and maturity delayed by temperatures below 5ºC for several days.
**Cultivars**

**Pumpkin/squash**
- White Boer type/Light grey: Flat White Boer Ford, Star 7001, Star 7022 Queensland Blue, Crown Prince
- Hubbard: Green hubbard, Chicago worted
- Patty pans: Patty pan, Sunburst, Sunny Delight
- Ceylon: Rovaal
- Marrows: Caserta (home gardens), Salvador, Ambassador, Star 8022
- Table squash: Table king, Table queen
- Baby gem squash: Star 8001, Rolet

**Watermelons**
- All Sweet (Fusarium and Anthracnose*)
- Charleston Grey (Fusarium and Anthracnose)
- Congo (Anthracnose)
- Crimson Sweet (Fusarium and Anthracnose)
- Evergreen
- Empire (Powdery Mildew, Fusarium and Anthracnose)
- Jupiter (Powdery Mildew)
- Odem (Powdery Mildew, Fusarium and Anthracnose)
- Sweet Baby (Fusarium)
- Sweet Princess (Fusarium and Anthracnose)
- Melons
- Hales Best, Hemed, Honeydew, Honeydew
- Green Flesh, Imperial 45, Lyon Jumbo, Saticoy

**Crop Rotation**
Keep the area free from weeds by hoeing and shallow cultivation. Rotate cucurbits with crops from other plant families e.g. leafy crops or legumes, to prevent spreading of diseases.

**Propagation**
Cucurbits are usually direct-seeded when all danger of frost has passed. Two or preferably three seeds are planted close to each other at the given distances within the rows. More than one seed is planted to ensure a good stand because cucurbit seedlings cannot normally be transplanted. Seedlings can also be made in peat pots or seedling trays with larger cavities. Muskmelons and watermelons are normally planted in this way to ensure early marketing.

**Sowing Time**
September to November in mild areas and August to October in warm areas.

**Soil Preparation**
Loosen the soil thoroughly by either ploughing or using a hand hoe, fork or a spade. All clods should be smashed by using a rake until you obtain a deep fine bed. Old manure, compost or fertilizer should be incorporated thoroughly into the soil during soil preparation. Cover crops (green manure) can be planted and worked into the soil 4-6 weeks before establishing the crop.

**Planting Method**
Cucurbit seed is planted 3.0 to 4.0 cm deep. Place 2 seeds per planting station, apart from each other. After 2 or 3 weeks, when the plants are growing well, the seedlings are thinned to a single plant. The excess plants can be moved if far enough from the remaining plants not to be disturbed and injured.

Under ideal conditions the field should be thoroughly irrigated before planting. The seed should make good contact with the seedbed and be covered with dry soil or soil that is not so wet that it forms a solid layer on drying. No irrigation should be applied before emergence as this may cause the formation of a crust. Should it rain before emergence and a crust does form, it should be kept damp with light overhead irrigation so that the seedlings can grow through.

During hot weather it is advisable to protect the soil surface from drying out by applying a mulch. After emergence the mulch should be removed to prevent the development of spindly plants.

**Spacing**
Traditionally pumpkins and melons are planted in rows 2 - 2.5 m apart, with plants spaced 0.5 - 0.6 m part in rows. However, many growers use a 2 m x 2 m spacing to allow for cross-cultivation. Butternut rows can be spaced closer 1 - 1.5 m apart. Where late season application of pesticides is anticipated, leave spray and harvest aisles.
Fertilization
All additions of lime, fertilizer or manures should be based on recommendations from a soil test. If necessary, lime should be applied 4 weeks before planting and incorporated to a depth of 20 cm. Soil pH(H2O) must be between 5.5 and 7.0. If recommendations are not available, then, approximately 1000 kg/ha (100g/m2) of a fertilizer mixture such as 2:3:4 (27) must be applied as a band 40 cm wide and one meter long, and worked into the soil very slightly just before planting.

Compost/manure may be used to supplement a part of the chemical fertilizer, e.g. 4 handfuls of manure/m2.

It is very important to apply a top dressing because a good leaf growth (canopy) is needed over the pumpkins and squashes to prevent sunburn of the fruit. Apply a top dressing 3 weeks after transplanting or emergence. Use 120-150 kg/ha or 10 g KAN/LAN fertilizer per meter of row, applied 10cm from the stem. A second top dressing can be applied 5 weeks later. Water well after fertilizer application.

Irrigation
Keep the soil moist throughout the growing season. It is important to irrigate regularly to avoid water stress. Cucurbits require uniform irrigation for optimum growth and yield. Reduce irrigations as fruits reach the harvest stage.

Pollination
Bees are an essential part of the production of all cucurbits. Wild bees and other insects are normally sufficient to pollinate small fields.

Harvesting
Carefully remove cucurbit fruit from the vines when they are mature. Be sure not to damage the fruits when harvesting, because this can lead to a shorter storage life and disease problems.
Squashes: 60-75 days
Butternut squash: 90-100 days

Muskmelons: 90-100 days
Winter muskmelons: 105-125 days
Watermelon: 95-120 days
Pumpkin: 120-150 days

Yield estimate for pumpkins and melons: 300 kg/m2.
Yield estimate for squash: 200 kg/ m2.

Storage
After pumpkins/squashes are harvested, they should be ripened or cured so they will keep longer in storage. Curing hardens the shell, heals superficial wounds, reduces the high water-content of the fruit, and improves the eating quality. The fruits can be cured by keeping them inside at room temperature for a week or two. Cucurbits require mild, fairly dry storage conditions. After the curing period, carefully place the fruits in a single layer on shelves, leaving a small space between each fruit.

Melons and watermelons require cool temperatures for storage.

Pests & Diseases

DISEASES
Powdery mildew
Caused by Sphaerotheca fuliginea, the disease starts as a white, powdery growth on the upper surface of leaves and on stems, often killing leaves. This causes reduced yield and poor fruit quality. Can be severe in hot, dry periods.
Control:
• Chemical control is essential
• Plant tolerant cultivars
• Control weeds

Downy mildew
Caused by Pseudoperonospora cubensis, the disease appears as yellow or brown spots on the upper leaf surface, with a grey/purple fungal growth on the lower leaf surface, particularly in wet, humid weather.
Control:
• Chemical control essential
• Plant tolerant cultivars
• Avoid over-irrigation
• Plant in well drained soils

Guidelines for the various types of cucurbits are:

<table>
<thead>
<tr>
<th>Cucumber</th>
<th>2.1 to 2.7 m rows</th>
<th>50 cm between plants</th>
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</thead>
<tbody>
<tr>
<td>Vegetable marrows (within rows)</td>
<td>1.2 to 1.5 m rows</td>
<td>50 cm between plants</td>
</tr>
<tr>
<td>Squashes (Butternut)</td>
<td>1.2 to 1.8 m rows</td>
<td>30 cm between plants</td>
</tr>
<tr>
<td>Squashes (Little Gem)</td>
<td>1.2 to 1.8 m rows</td>
<td>30 cm between plants</td>
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<tr>
<td>Cucumbers</td>
<td>1.2 to 1.5 m rows</td>
<td>30 cm between plants</td>
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<tr>
<td>Watermelons</td>
<td>1.8 to 2.4 m rows</td>
<td>50 cm between plants</td>
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<tr>
<td>Muskmelons</td>
<td>1.5 to 2.0 m rows</td>
<td>30 cm between plants</td>
</tr>
</tbody>
</table>
Production guidelines

**Fusarium wilt**
Caused by *Fusarium oxysporum*. Plants wilt and die. When the lower stem is cut open, stem tissues are light brown in colour. The pathogen can be seed-borne. The disease favours warm soil temperatures.

*Control:*
- Plant disease-free seed
- Plant tolerant varieties
- Adjust soil pH to 6.5 using nitrate nitrogen
- Practice field sanitation
- Control nematodes.

**Gummy stem blight/Black rot**
Caused by *Phoma cucurbitacearum*. Infected plants show gummy stem lesions causing the plant to wilt and die. Small, black, pinpoint sized fruiting bodies of the pathogen are just visible in stem lesions. In butternut, a characteristic large whitish brown fruit rot develops which is known as Black Rot.

*Control:*
- Disease-free seed
- Chemical control
- Avoid over-irrigation
- Field sanitation.

**Phytophthora crown and root rot**
Caused by *Phytophthora capsici*. The lower stem and roots become brown and rot, causing plants to wilt and die. Fruits rot quickly and have a white growth on the outside.

*Control:*
- Chemical control
- Avoid over-irrigating plants
- Well drained soil
- Use clean water (borehole or municipal water)
- Crop rotation.

**Angular leaf spot**
Caused by *Pseudomonas syringae pv. lachrymans*. Brown spots on the leaves bounded by veins, giving the spots an angular shape. Spots surrounded by a yellow margin.

*Control:*
- Disease-free seed
- Crop rotation
- Avoid overhead irrigation
- Tolerant varieties.

**Viral diseases** are the most limiting factor to squash production, particularly during summer and autumn months. Symptoms include a mosaic pattern on leaves that in severe cases causes a shoestring effect. Fruits can be malformed and bumpy and seeds can also be malformed.

Virus diseases of pumpkins (and squash) may be caused by any of several different pathogens: cucumber mosaic virus (CMV), squash mosaic virus (SqMV), watermelon mosaic virus (WMV), and zucchini yellow mosaic virus (ZYMV).

Virus spread - These viruses are transported mainly by infected seed or insect vectors such as aphids or cucumber beetles.

**Control measures**
Control measures should include controlling insect vectors. Virus-infected plants should be rouged and removed from the field and destroyed. For the seed borne viruses, it is important to buy disease-free seeds from certified seed companies. These are the only control measures against viruses.

**PESTS**

**Aphids**
Aphids are soft-bodied insects that often appear in clusters. They are very small and may be green, red, brown, or black. They suck plant juices and transmit viral diseases.

*Control*
Control with registered chemicals. On smaller plots spray with light liquid soap or repellent mixes e.g. onion and garlic extracts.

**Pumpkin fly**
Pumpkin flies sting young fruit (usually smaller than 10 cm) and lay eggs in cluster under the peel. Infected fruit get infected with pathogens and rot.

*Control*
A preventative control method is putting out bait consisting of Dipterex, sugar and water when flowering starts. Control with pesticide every 7-10 days.

**Cucurbit leaf beetles**
At least three common cucurbit leaf beetles attack pumpkins in South Africa. They are all black and orange. They damage flowers and leaves.

*Control*
Cucurbit beetles must be controlled when they are first noticed in the spring. They will continue to migrate into cucurbit fields over a period of a few weeks. Daily scouting is essential during the emergence and early life of the crop while the plants are small and susceptible.

Sanitation is a good preventive strategy. Remove plant debris as soon as possible after the crop is harvested and remove any objects, for example - field containers, wagons, or machinery - that will provide the shelter these insects need in order to survive the winter.

**CROP MANAGEMENT**
Control weeds through frequent, shallow cultivation. Although pumpkins and squash are deep-rooted, most roots are near the surface. Deep cultivation is very harmful, destroying many of the fine roots near the soil surface. Hand-weeding and hoeing is usually required. As the plants cover the ground, they shade out many weeds.
Green beans (Phaseolus vulgaris) are a legume that has been used as food for centuries, and is today still one of the most important foodstuffs utilized by mankind. The pods contribute vitamins such as vitamin C, and minerals such as calcium, iron, folic acid and riboflavin (vitamin B2) to the human diet. Green beans are a popular vegetable and are grown in home gardens. Green beans are a tropical crop and consequently sensitive to low temperatures. In general farmers plant both bush as well as runner varieties.

**Soil**
Green beans can be successfully cultivated in soils which range from sandy to reasonably heavy clay soils. They prefer deep, well-drained soils, with good water retention ability. The best yields are achieved in medium loam soils. Avoid soils making a crust, as this will have a negative effect on emergence of seedlings. A soil pH of 6.0 to 6.5 is recommended.

**Climate**
Because of its tropical origin, green beans cannot be successfully cultivated in areas with temperatures below 10°C and they are very sensitive to frost. The optimum temperature is between 16°C and 24°C. Temperatures above 35 °C, if accompanied by dry winds, may cause the flowers and tender pods to abort resulting in poor yields.

**Cultivars**
- Bush beans: Wintergreen, Contender, Class Act, World Cup, Imali, Malelaan, Star 2000, Star 2052
- Runner beans: Witsa, Lazy Housewife

**Crop rotation**
Green beans should be rotated with other non-leguminous crops to avoid possible transmission of diseases such as bacterial blight, anthracnose and fusarium-wilt. As a result of their nitrogen-fixing ability, green beans help to build up the soil nutrient status.

**Propagation**
Green beans establish well by direct sowing.
Production guidelines

Spacing
Plants are established from seeds. The optimum spacing for bush beans is 60cm between rows and 5cm between plants in a row (32 plants/m²). For runner beans a wider spacing is used: rows 1m apart and plants spaced 10cm apart in the row. To reduce costs of trellising, 3 plants can be trellised to one support.

Soil Preparation
Loosen the soil thoroughly by either ploughing or using a hand hoe, fork or a spade. All clods should be smashed by using a rake until you obtain a deep fine bed. Old manure, compost or fertilizer should be incorporated thoroughly into the soil during soil preparation. Cover crops (green manure) can be planted and worked into the soil 4-6 weeks before establishing the crop.

PLANTING TIME

<table>
<thead>
<tr>
<th>PRODUCTION AREA</th>
<th>PLANTING TIME</th>
<th>PLANTING TIME</th>
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<tbody>
<tr>
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<td>Middle September to January</td>
<td>Middle September to December</td>
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<td>Middleveld (light frost in winter) of Gauteng, Northern Province, Mpumalanga &amp; KwaZulu-Natal.</td>
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<td>Lowveld (cooler areas of Mpumalanga, Northern Province &amp; KwaZulu-Natal).</td>
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<td>Lowveld (with very hot summers &amp; frost-free winters) of Mpumalanga, Northern Province &amp; KwaZulu-Natal.</td>
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<tr>
<td>Eastern Cape</td>
<td>October to February</td>
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<tr>
<td>Western Cape</td>
<td>September to February</td>
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**Fertilization**

**General fertilizer recommendation:**
Before planting, approximately 1000 kg/ha or 100 gram/m² 2:3:4(27) must be applied and worked into the top 10 cm of the soil.

After planting, apply a top dressing of 10 gram LAN/m² at 2 and again at 4 weeks after planting. Be careful not to apply LAN or any other nitrogen fertilizer directly onto the plants, because this will burn the leaves. Apply 5-10 cm away from the plants at both sides. Water the plants immediately after the fertilizer has been worked into the soil.

Or use organic fertilizers before planting e.g. compost or manure (4 handfuls of manure/m²). Cover crops (green manure) can be planted and worked into the soil 4-6 weeks before establishing the crop.

**Irrigation**

Roots will develop and utilize water and nutrients up to 400 mm down into the soil. Approximately 450 mm of water is required during the growing season including rainfall. A general guideline is 35 mm per week.

Green beans dislike water on the seed while germinating (5-7 days after sowing). After sowing water properly and wait for emergence. From the flowering stage, green beans are very sensitive to lack of moisture, so it will be necessary to apply 35 mm per week until the pods have been harvested.

**Harvesting**

Green beans generally take 60 – 90 days to mature. Repeated harvests when the pods are still young, will induce the formation of new flower buds which will result in a higher yield of young pods.

It is important to harvest at the right stage and the following method can be applied: When the pod is cut open lengthwise, the seed must be well developed, but be careful because the seed can harden very quickly. Beans ripen very quickly in warm weather and therefore it is necessary to harvest every day to get good quality pods. It is important to harvest early in the morning, and pods must not be left in the sun as they wilt quickly (within 2 to 4 hours).

To ensure good keeping quality for the fresh produce market, green beans must be cooled and stored at 4 to 7 °C. Estimated yield: 100 kg/100m².

**Pests**

- **Bean seed beetle**
  Damage the seed during storage.

- **Seed bean maggot**
  This pest causes poor seedling emergence. The maggots feed on the young seedlings. A sporadic pest.

- **CMR-beetle**
  Feeds on all above-ground parts of the plant especially the flowers.

- **Brown beetle**
  Active at night and cause damage to the leaves.

- **Thrips**
  Damage young developing pods.

- **African bollworm**
  The caterpillar penetrates the pods and continues feeding inside.

- **Plusia looper**
  Damage pods in the field.

- **Tip wilter**
  Flat-backed, blackish, insects. They attack soft growth points by sucking out plant sap and injecting toxins that causes the plant to wilt. Damage is similar to that of the green vegetable bug.

**General control measures for the above insects:**

Scout regularly
Apply pesticides. Consult your agricultural supply outlet for recommendations.
Apply insect repellent sprays e.g. onion and garlic mix.

- **Aphids**
  Suck sap from plants, and transmit virus diseases.
  Control: Spray with soapy water. Spray repellent mixes e.g. onion and garlic mix.

- **Red spider mite**
  Present on the underside of leaves where they feed on plant sap and spin silk threats and webs. Small light yellow specks appear on the upper leaf surface.
  Control: Regular scouting is very important. Spray with registered miticides.
**Root knot nematode**
Infested plants show signs of retarded growth. The roots are malformed with small growths on the roots. Infested plants can die before they start to produce fruit.
Control: Fallowing. Practice crop rotation. Cropping with marigolds, castor beans, chrysanthemums. Soil solarisation – cover tilled, slightly moist soil with clear plastic sheeting for 6-8 weeks in sunny areas.

**Diseases**

**BACTERIAL DISEASES**

**Bacterial blight**
Caused by Xanthomonas phaseoli. Small to large brown spots with yellow margins occur on leaves. Water-soaked spots occur on the pods.
Control:
- Use disease-free seed
- Chemical control
- Crop rotation
- Sanitation practices

**FUNGAL DISEASES**

**Anthracnose**
Caused by Colletotrichum lindemuthianum. Reddish-brown leaf spots and sunken lesions on the fruits.
Control:
- Use disease-free seed
- Chemical control
- Crop rotation

**Ashy stem blight**
This is caused by Macrophomina phaseolina. Stems and pods are grey/white and contain small black bodies called sclerotia..
Control:
- Use disease-free seed
- Optimal fertilization and irrigation
- Crop rotation
- Plant in well drained soil

**Fusarium root rot**
Caused by Fusarium spp. Stems show a brown rot at soil level, and roots are brown.
Control:
- Chemical seed treatment
- Optimal fertilization
- Good drainage
- Crop rotation.

**Rhizoctonia root rot**
Rhizoctonia solani causes this disease. Stems show a dark brown, lower stem rot and root rot.
Control:
- Chemical seed treatment
- Pre-plant chemical drench
- Shallow planting
- Crop rotation with non-host crops

**Rust**
Caused by Uromyces appendiculatus. Leaves are covered with round, reddish-brown powdery spots.
Control:
- Chemical control
- Resistant cultivars
- Crop rotation with non-host crops

**Scab**
Caused by Elsinoë phaseoli which attack leaves, stems and pods showing raised red/brown necrotic areas.
Control:
- Use disease-free seed
- Crop rotation with non-host crops
- Chemical seed treatment

**VIRAL DISEASES**

**Bean mosaic virus**
The margins and tips of the leaves curl down. The leaves show a typical yellowish-green mosaic; dark-green bands along the veins show up against the lighter green of the leaf. This is a seed-borne virus.

**Yellow mosaic viruses**
This group of viruses causes bright yellow spots on the leaves. Infected leaves are often misshapen. The disease can cause considerable crop losses.

**Necrosis viruses**
This group of viruses causes dwarfing of infected plants. Leaves, stems and other organs become completely or partly brown and die. This disease can cause severe damage.
OTHER AFRICAN LEAFY VEGETABLES

Lerotho, Bangala, Spider flower - Cleome gynandra Guxe, Delele, Jew’s mallow - Corchorus olitorius Muchaina, kale - Brassica carinata and B rapa

Introduction

Marogo or imfino (Leafy Vegetables – ALV’s) is well known to thousands of South Africans. It is harvested in the veldt and with “styfpap” (stiff porridge) it forms the staple diet of many households. These leafy vegetables can be grown in home gardens, where it is easily harvested and a steady supply could be ensured. There is a large potential for these rapidly maturing crops to fit into multiple cropping systems (rotation systems) with conventional vegetables. Leafy vegetables are rich in minerals (e.g. iron) and vitamins (e.g. vitamins A and C).

Soil requirements

Sandy, sandy loam and loam soils is preferable but ALV’s will grow in almost all soil types. Kale does not like wet feet.

Climate requirements

Optimum temperatures vary 15 to 30°C, depending on species. Corchorus prefer day temperature of about 30°C and both Cleome and Corchorus are sensitive to cold. Cleome needs sunlight and does not grow well in the shade.

Cultivars

No cultivars are released yet.

Crop rotation and intercropping

Most of the African leafy vegetables could be intercropped with ach other or with maize. For instance, Spider plant could be a companion crop for nightshade and amaranths. The fast growing spider plants are harvested before the other two.
**Sowing methods**
Prepare a fine seedbed. Make shallow furrows 1.5 – 2.5 cm deep, 25 – 35 cm apart. Mix seed with sand or dry soil, for even distribution, and sow seeds evenly in the rows. After sowing cover the seed with soil and apply water with a watering can.
Thin plants out or transplant when seedlings are 15 cm tall, or sow direct and thinned at 5 weeks.
Thin the seedlings out to an in-row spacing of 10 – 15 cm depending on specie and growth habit of line. Seed could also be broadcasted in fine seedbeds. Water every day but during hot, dry seasons water twice a day.
Germination of spider flower could be uneven and make sure that dormancy of Corchorus seed is broken before sowing.

**Spacing**
Small crops: 10-15 cm between plants  
Large crops: 20-30 cm between plants  
30-50 cm between Rows

**Fertilization**
Work in well ripened manure (±2-3 kg m2) or 0.6 -1 kg per meter in rows) before planting.  
Use half or quarter of the above amounts if using chicken manure. High levels of nitrogen manure will delay flowering and increase the leaf yield. 100 gram of ash per m2 bed could be added for corchorus.

**Harvest**
Harvesting can be done by uprooting, cutting back (± 15 - 20cm) or picking the leaves. Once plants are growing well, frequent harvesting of leaves or shoots can take place.
When possible, harvest early in the morning or late in the afternoon when it is cool. Place uprooted plants in water. Shoots and leaves can be wrapped in wet cloth or placed without water in well-ventilated bags overnight. Water can be sprinkled on, but sparingly to avoid rotting. Dip shoots in water for about 30 minutes the next morning to revive it.

**Pest & Diseases**

**Cleome**
Flea beetle, nematodes, stem borer, pod borers and cutworms.

**Corchorus**
Pests and diseases are almost never a problem.

**Kale**
Aphids, Mosaic virus, Diamond back moth.  
**Control:**
Use registered chemicals to control virus vectors  
Apply strict sanitation practices during the growing season  
Monitor / scout crops for important pests and diseases

**Crop management**
Plants require water 2 or 3 times a week. Drought will hasten development of flowers and lower the yield.

Start weeding when the seedlings are established and this process must continue at least until the leaves cover the ground or till end of season.

**Seed Production**
Collect seeds from healthy, disease-free plants. Harvest when the pods are fully dry, just before they open naturally in the field. Dry seeds in the shade on cloth or dry grass, but never on concrete or corrugated iron.

Store dried seed in a closed container so that insects cannot damage it. Add ash and charcoal to the containers to keep the insects away. Try to store the containers with seed in a cool, dry and dark place. Never place green seeds in a closed container, the seeds will rot.
Agricultural research in South Africa

The ARC Roodeplaat Vegetable and Ornamental Plant Institute (ARC-VOPI) was established in 1949 and, over the ensuing 60 years, has conducted needs-driven, environmentally friendly research, technology development and technology transfer with regards to vegetables, ornamental plants, hydroponics, medical plants, African leafy vegetables, sweet potatoes.

The Institute’s role is to provide appropriate, sustainable technologies for breeding, production, protection and conservation of crops to enhance food security and nutrition, global competitiveness, and the growth and commercialising of the vegetable and flower sectors.

The core research divisions are Crop Science, Plant Breeding (including biotechnology and gene banks) and Crop protection.

Research ensures access to sufficient, safe and nutritious food. This helps to address the huge malnutrition problem in our country, and many other parts of the world.

Optimised growth, a contribution to job opportunities and income, are ensured through the Institute’s research.

Risk management, important to minimise crop losses, is achieved through strategies such as effective disease forecasting systems, disease diagnostics, the monitoring of new disease outbreaks or changes in current microbial populations.

Agriculture, one of the largest sectors in the country, is undergoing radical change, driven by major trends in the macro-economic, social and natural environment. These trends focus on the increasing importance of the marketplace and rapid shifts in power along the food supply chain. More and more, farmers have to face rapidly increasing production costs and decreasing prices for their produce.

Raw commodity prices are decreasing, but the food sector is showing rising profits and this results in increased food prices to consumers.

Post-harvest components of the food systems are also becoming important. In future, it will be increasingly important to link farmers and agro-processors to markets, and find ways to add value to agricultural crops and develop new ones adapted to altering environments as a result of climate change.

We need to find innovative ways to enable existing and new farmers to produce crops profitably in a very competitive global market.
Vegetables are rich in micronutrients, minerals and vitamins and can play an important role in combating food scarcity and malnutrition, since most of them can be produced very successfully in home gardens.

In south Africa 64% of 1-9 year old children are vitamin deficient. In addition 27% of women of child bearing age have the same deficiency. Vitamin A is required for normal functioning of the immune system and for eye health. Pro-vitamin A is obtained by eating consuming yellow and orange vegetables (e.g. carrot, Orange fleshed sweet potato) and dark green leafy vegetables.

More than a quarter of the world's chronically hungry people live in countries where the prevalence of undernourishment is very high. The problem is especially severe in central, east and southern Africa; more than 40% of households in South Africa live in "food poverty" and are unable to afford a basic subsistence diet.

The major staple food crops in South Africa are maize and wheat, and the daily nutritional uptake in rural communities is below the basic requirements for a healthy diet.

South Africa’s food and agricultural policy historically placed national self-sufficiency as a major objective.

Until recently this goal was largely met, as a surplus was produced in most major agricultural commodities. It has, however, become increasingly difficult for the agricultural sector in South Africa to provide sufficient quantities of food at affordable prices.

Constant rising food prices are especially affecting poor households in South Africa. This state of affairs holds a serious threat for social stability in the country and food diversification is considered a sustainable long-term approach to combat malnutrition, already considered a public health problem. Government has recently instructed its social and economic cluster departments to provide starter packs for household vegetable production, family gardens and school nutrition schemes.

Farmers need to be trained, however, and given information on cultivation practices for selected vegetable crops on a regular basis.

In addition to the wellknown commercial vegetables, the ARC Roodeplaat is also involved in researching a variety of indigenous and lesser used vegetable crops. For example, Amaranthus (morogo), is a good source of calcium, magnesium, carotene, iron and vitamin C; its roots and seed are proteinrich and it can be grown in home gardens.

The ARC’S role as a partner and advisor lies in ensuring the end results are achieved through research, technology development and technology transfer.
Lack of skills, knowledge and information has been highlighted as key factors contributing to poor agricultural productivity. The ARC has embarked on a drive to provide agricultural services to assist farmers of all categories to address these challenges.

The core business of the ARC is to conduct fundamental and applied research with partners, to generate new knowledge, develop human capital and conduct technology transfer to foster innovation in agriculture. Commercialization of intellectual property and dissemination of technologies developed at the ARC ensures that the organisation continues to support the agricultural sector, thus contributing to its competitiveness and its ability to create jobs in a vibrant economy.

The ARC provides the following four types of services to clients in the farming sector:

**Training in agricultural production**
The objective of the ARC Training Services is to address the information gap between research and development (R&D) and the end user of the research output. ARC researchers have developed more than 120 short courses to address various skills needed for a thriving agribusiness, incorporating those specific to a commodity and generic business skills. Courses are customised to meet the needs of the different clients in the sector. Our most popular courses are: Beef Cattle Management; Cheese and Yoghurt making; Hydroponics Vegetable Production; Beekeeping, Mushroom Production and Integrated Pest and Disease Management. The ARC is an accredited Agricultural Education and Training provider.

**Analytical**
The ARC provides comprehensive soil analysis to determine the composition, nutrient content and measure of fertility. Recommendations to remedy deficiencies and improve soil fertility are provided to add value to the service and provide the customer with practical advice on steps to be taken.

**Disease diagnostics**
Farmers are constantly faced with the threat of disease and plagues that can severely harm their livestock and crop production. The ARC helps provide professional diagnostic services to help detect and diagnose pests and pathogens before they can cause major harm to farming enterprises. These services include disease monitoring surveillance, identification of disease-causing pathogens and advice on preventative programmes.

**Consultancy**
The ARC has extensive competencies in the consultancy services and provides services in Biological Statistics (Biometry), Economic Analyses including impact and feasibility studies, Development Project Planning, Landuse Planning and Enterprise planning.
he principal agricultural research institution in South Africa, the Agricultural Research Council (ARC), was established by the Agricultural Research Act, No 86 of 1990 (as amended). It is a schedule 3A public entity in terms of the Public Finance Management Act 1 of 1999, as amended by Act 29 of 1999.

The Act sets out the objectives of the ARC as “conducting of research, development and technology transfer in order to: Promote agriculture and industry. Contribute to a better quality of life. Facilitate and ensure natural resource conservation.”

The organisation performs its functions through the following research campuses, commonly known as research institutes, that are predominantly commodity-based and are strategically distributed throughout the country:

- **Animals (livestock)**
- Animal health (Onderste poort Veterinary Institute).
- Animal Production Institute.

- **Grain and industrial crops**
- Institute for Industrial Crops.
- Small Grains Institute.
- Grain Crops Institute.

- **Horticulture**
- Institute for Tropical and Subtropical Crops.
- Infruitec-Nietvoorbij.
  Vegetable and Ornamental Plants.

- **Natural resources and engineering**
- Agricultural Engineering Institute.
- Institute for Soil, Climate and Water.
- Plant Protection Research Institute.
<table>
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<tr>
<th>ARC-Central Office (Hatfield)</th>
<th>ARC-Infruitec/Nietvoorbij</th>
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<tbody>
<tr>
<td>1134 Park street, Hatfield, Pretoria</td>
<td>Corner of R44 and Helshoogte Road, Stellenbosch</td>
</tr>
<tr>
<td>P.O. Box 8783, Pretoria 0001</td>
<td>P/Bag X5026, Stellenbosch</td>
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<tr>
<td>Tel: 012 427 9700</td>
<td>Tel: 021 809 3100</td>
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<tr>
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<td>141 Cresswell Road, Silverton</td>
<td>114 Chris Hani Drive, Potchefstroom</td>
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