Horticulture Manual for Schools: A guide to establish and sustain food gardens

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PREFACE

South Africa is among countries that are in nutrition transition which includes the co-existence of under - and over-nutrition and has malnutrition and food security problems. Several studies report dire deficiencies of micronutrients, particularly vitamin A, iodine, iron and zinc, in the diet of most South African children. Consequences are impaired immune system, reduced mental capacity, fatigue, dizziness and poor physical development. These nutritional problems generally reduce learning capacity, resulting in poor school performance and early drop out.

The National School Nutrition Programme is a school-based intervention to address the problem of hunger and malnutrition among children. The programme further promotes nutrition education for educators, learners and parents through school gardens, extra- and co-curricular activities. The school gardens are used as a vehicle to develop knowledge, attitudes, values and life-skills related to food and nutrition. The schools are assisted to establish and sustain manageable food gardens where educators, learners and parents will learn how to grow, tend and harvest a variety of vegetables and fruits.

Horticulture Manual for Schools is designed to provide educators and other stakeholders who will be working with the schools with comprehensive information on how to start and manage school gardens. The manual is organized into eight parts which are systematically arranged to address the different aspects of horticulture and nutrition education. Educators will use it as a reference for general gardening theory and practical and to inform garden-based teaching for other school subjects.

Information is kept simple so that learners and parents can use it for their home gardens. It is envisaged that the manual will be a practical tool for schools and communities who are yet to start food gardens and for improving existing ones.

1. INTRODUCTION

1.1 Reasons for having a school food garden

The National School Nutrition Programme (NSNP) is an effective intervention to alleviate short-term hunger as well as to increase school enrolment and attendance. It also facilitates community participation in other interventions that are based on small-scale actions such as school food gardens and nutrition education.

Sustainable Food Production in Schools (SFPS) is a sub-programme of NSNP intended to impart knowledge and practical skills on food production (gardens, small stock rearing, food preservation), nutrition education and sustainable use of natural resources. School gardens transform a barren schoolyard into an attractive space that reconnects learners to the natural world, creating an outdoor environment that promotes creative thinking, active learning and interpersonal skills.

School gardening is considered an important complement to school meals through provision of fresh vegetables. It also has the potential to change attitudes and values towards the rewarding hands-on blue collar activity, hence it has a long term impact on the learner. Involving parents in school garden projects encourages community participation by application of principles and skills developed at home. Increase in the number of motivated and informed participants will impact positively on food security and nutrition at household level. The aim is to mobilize and capacitate school communities to play a role in alleviating hunger and reducing malnutrition.

School gardens can fulfill many possible roles in the lives of learners and communities.

School gardens should be places where

- concepts in various learning areas can be clarified and demonstrated such as:
  - studying insects and plants
  - numeracy e.g. calculating the yield, conversions, measuring irrigation or rainfall;
- people meet people (learners, parents, teachers, community members and visitors) and everyone learns;
- it is good to work and study;
- events take place – food production, food fairs, selling produce to the public;
- work is displayed – garden art, demonstration at the garden, accounting & record keeping.

The aims of a school garden are:

1.1.1 To develop skills and knowledge of learners, teachers and parents

Skills and knowledge are key to development of society as it is transformed from dependence on food handouts to selfreliance. Knowledge and skills can be developed through (a) structured content on food production (vegetable or small stock rearing) and (b) linking activities in the food gardens with school subjects such as natural science, agriculture, life science, numeracy, languages and technology. The garden provides an excellent resource to teach these subjects while allowing the learners to learn in an environment that is different from the sterile classrooms to which most learners are accustomed. In a school garden the learners work in a non-threatening outdoor environment.

1.1.2 To link with the Nutrition Education

The Nutrition Education (NE) component of the NSNP aims to promote healthy food choices and good eating habits among school communities. The school with healthy nutrition environment settings such as food garden provides an excellent opportunity to link food production with healthy food choices and eating habits. Nutrition education through school gardens increases children's knowledge about fruits and vegetables, which may improve their attitudes towards these foods and lead to better eating habits. In this way healthy lifestyles are taught to young people who can then take this knowledge home to influence other family members.

1.1.3 To strengthen school feeding

School gardens are a cost effective method of augmenting the school meals especially when considering the high food prices. It is further necessitated by the fact that one meal is served to learners, of which for some it is the only meal of the day and the produce from the garden can enable the school to give more on the plates of needy children. Uncooked produce can be offered as take-home rations for needy learners.

1.1.4 To benefit household food production

School gardens provide the opportunity for learners, educators and members of the community (parents) to interact. This interaction can teach them how to work cooperatively with each other and influence the practice of growing of vegetables, fruit and herbs for the households.
This will have a positive impact on community development. Household food gardens will improve access to food and may also generate income for the families. The learners and parents obtain skills on basic crop production and the importance of having a sustainable food supply.

1.1.5 To earn income and develop business skills

Although generating an income is a secondary aim of school gardens, income can be generated to purchase inputs to sustain the gardens and other necessities for the school. Good prices will be obtained only for quality vegetables. It is important to set prices to cover all expenses incurred in the production. This is why the business management aspect is also important. This includes planning, record keeping, marketing and financial management. School gardens provides an opportunity to teach business skills that can enhance learners' ability to become self-sustainable and independent once they complete school.

1.2 Success stories

School gardens transform a barren school yard into an attractive space that reconnects learners and teachers to the natural world. They create an outdoor environment that promotes creative thinking, active learning and interpersonal skills. Below are some of the beautiful sites found at schools around the country:

Xihlovo Primary School (Limpopo)

Xihlovo Primary School (Limpopo)

Namo Primary School (Gauteng)

Diamanthoogte Intermediate (Free State)

2. MANAGEMENT AND ADMINISTRATION OF A SCHOOL GARDEN

2.1 Administration of the garden

The school garden should be managed in a way that:

- It is an area for learning and developing life and survival skills;
- It teaches the learners to respect the environment, plants and animals;
- It makes the learners proud of their school environment;
- It is a place of pleasure and recreation and that creates positive attitude;
- It is a source of food for improving learners' diet and health;
- Time is provided for learners to work in the garden.

2.1.1 Challenges

Schools should be aware of the possible challenges which they may encounter when establishing and sustaining their food gardens. These include:

- lack of basic resources such as water, fence, seeds, seedlings and garden tools as well as sufficient funding to provide for them;
- poor quality soils and harsh climatic conditions such as drought, floods and frost;
- insufficient knowledge and skills on crop production and garden management;
- lack of motivation, support and commitment from school management teams and parents;
- theft and vandalism.

(Castle & Bialobrzeska, 2009; DoE, 2008a; 2008c; PSC, 2008)

To overcome them, the following need to be addressed, preferably before starting the garden (See also Part 3: Planning).

2.1.2 Leadership and ownership

What help can be given by community

The school should look for people who can contribute any of the four W's – Wealth, Wisdom, Work and Weight (influence)" (FAO, 2005)

The principal as the head of the school's governance teams should take a lead in the general management of the school garden. Management responsibilities can be delegated to one of the educators, a gardener or any experienced parent from the community.

The garden manager should be a member of the Nutrition Committee. He/she must work with the committee in jointly planning and managing, finding the required resources, motivating other role players to participate and allocating the responsibilities to them, aligning the schedules for learners' activities and planned lessons that can make use of the garden and publicizing garden achievements. The committee must ensure that routine responsibilities are carried out without much supervision.

2.1.3 Important stakeholders and responsibilities

It is important for the school to realize that not everyone will share their excitement. Send out invites in different languages and media to all the parents. Use one of the parents and community members with a helpful, encouraging and enthusiastic attitude to coordinate the networks. Do not pressure anyone to become involved. Start small networks and others will begin to notice.

While the school gardens are the responsibility of the school (teachers and learners), they become more successful when the parents and other community members and sectors are involved. Their involvement should be from the planning phase so that they can share the vision, ownership and commitment. For successful establishment and maintenance of school gardens close collaboration as well as a clear definition of roles and responsibilities among stakeholders and role players is required. The school must establish and know what each partners can contribute.

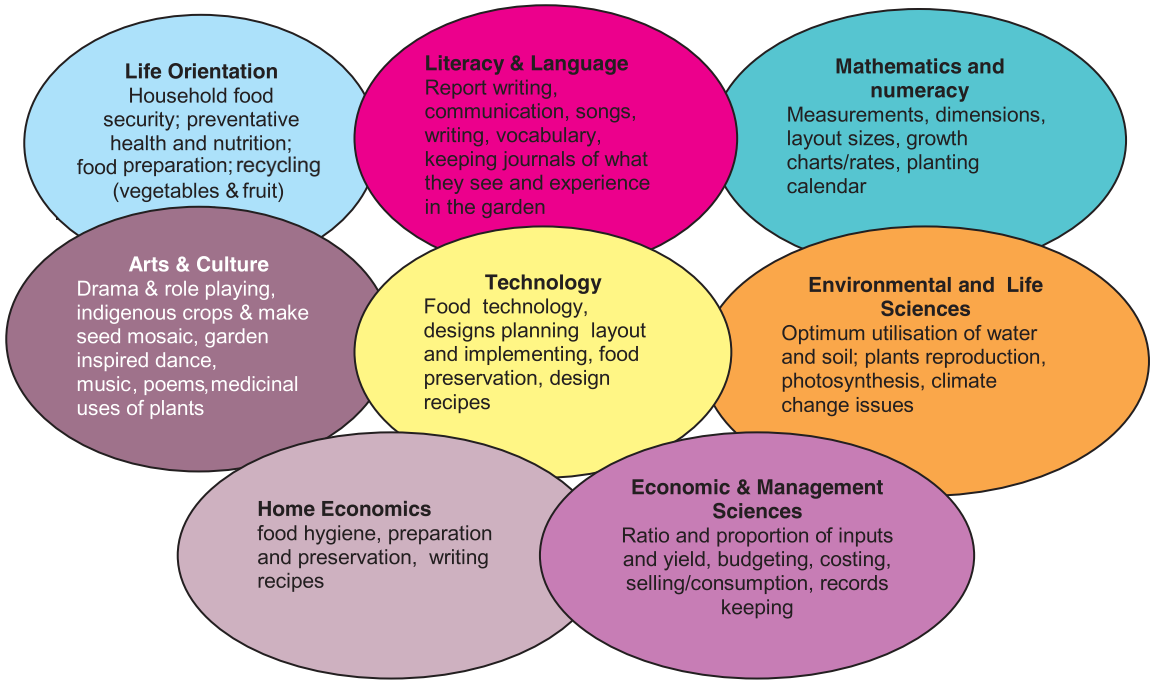
Tasks such as who is responsible for acquiring the tools, seeds and seedlings, for the garden layout and crops to be planted, for sponsorship and advice, supervision of the gardener, and who will manage income and expenses have to be clearly defined. Begin building the network by conducting a brainstorming meeting with potential supporters. Accurate records must be kept with regard to material and financial support from the sponsors. The school should acknowledge all support received, large or small. This can be done in the form of notes, posters, banners, etc and the learners should be involved in the acknowledgement process.

(a) Educators

All the educators need to contribute towards the success of the school garden. It is more fun to approach the garden project as a teaching team and it takes the burden off one person to keep the project alive. Educators are vital contributors because they understand curriculum goals and they can use the garden in their own teaching by making it an interactive educational resource.

There must be a learner participation schedule which will guide the schools on which class goes out to learn which topic(s) and what gardening activities will be done to develop skills and to sustain the garden. Educators can also facilitate establishment of environmental clubs which will include gardening in their activities. A school garden, therefore, becomes a resource for both curricular and extra-curricular activities.

Possible integration of garden activities with school subjects:



(b) School support staff (Non-teaching staff)

Gardeners, grounds men, cleaners and food handlers should be involved as they know the school environment well and are always on the premises. Food handlers can be consulted on the vegetables that must be planted because they know what the children eat most. Some gardeners have considerable knowledge and skills which can be shared with teachers and learners. The goal is to equip all with knowledge and skills and to encourage them to establish home gardens which can improve access and the consumption of vegetables. The school should include them in the training and where possible provide them with seeds and seedlings for their home gardens.

(c) Learners

The main aim of the school gardens must be to teach the children to plant, tend and harvest vegetables in order to eat healthy . Each learner must get an opportunity to partake in food production so as to acquire knowledge and skills. However, it must not be too frequent, lengthy and laborious. Learners can be divided into groups (*or according to classes*) so that they can take turns working in the garden and thus share the responsibilities. Each grade, led by an educator, may be responsible for a crop or a specific plot. A thirty-minute period per week should be enough for each class to do garden activities. The school can provide the learners with seeds and seedlings for planting at home. Using the garden (activities) to punish learners should be forbidden at all costs. Valuing the learner's opinions and encouraging them to make decisions can yield motivated, confident and collaborative learners.

Learners in school gardens: (A) Maxonia Primary (Western Cape); (B) Malekgere Secondary School (Gauteng) (C) Canzibe Primary School (Eastern Cape); and (D) Tau Sebele (Gauteng) singing the locally composed vitamin A song.

(d) Parents and community

It is important for parents and the community in general to be involved in school gardens.Schools which have successful garden projects acknowledge the active involvement and contribution of parents. Participation of parents include assisting schools by lending them tools, providing advice and organizing "letsema / ilima" to complete heavy work such as clearing, tilling and harvesting. Households can buy excess seedlings and harvest from the school or they can donate these to the school.

Where land is sufficient parents to can be allocated a portion in the garden where they can grow their own vegetables while assisting the school to manage its production. There must be a clear agreement with the SGB on how there can be mutual benefit between the school and those involved. This can be in a form of sharing the harvest.

According to the South African Schools Act (Act No 84 of 1996), for schools established as public schools on private property, it is incumbent upon the SGB to seek permission (preferably in writing) from the property owner, and to agree on matters such as where to lay out the garden and access to water before starting a garden. The SGB/parents can liaise with traditional authorities concerning more space on tribal land and contact the local municipality concerning water availability.

(e) Public sector services

In South Africa the school garden programmes are developed as part of the government effort to improve quality and access to education for all children, to promote nutrition education, to improve access to quality food and sustainable management of natural resources. The design and implementation of the programmes and activities at the national, provincial, district and local municipality levels should, therefore, involve the Departments of Education, Agriculture, Forestry and Fisheries, Health, Rural Development and Water and Environmental Affairs as well as District and Local Municipalities

Their responsibilities include:

- the adjustment of curriculum to accommodate integration of school gardening activities as part of core or extra-curricular activities;
- training of schools and participating community members on garden management and horticulture;
- preparation and provision of guidelines and training materials;
- provision and upgrading of school garden infrastructure such as irrigation systems (boreholes, water points, roof catchments, etc.), fencing and land;
- monitoring and evaluation of progress and intervening where progress is slow.

(f) Non-Governmental and community based organizations, business community and volunteer organizations

Sponsors are an important source of support and income for obtaining agricultural supplies, especially during the initial phases. However, the school garden must not be dependent on outside funds to keep it going. The sooner the garden can be independent, the better. If ownership and commitment comes first, this will be possible. Support can be in the form of money, training, garden inputs and equipment, organizing and awarding prizes for garden competitions and profiling the school garden in the local community events.

2.1.4 Crops to produce

In order to ensure adequate exposure of the school community to methods of production and the intake of healthy foods, it is necessary to grow a wide a variety of vegetables. A balanced diet is necessary to keep the human body healthy, hence the need to eat a variety of foods everyday.

South African Food Based Dietary Guidelines

For adults and children over the age of seven years:

- Make starchy foods the basis of most meals;
- Eat dry beans, split peas, lentils and soya regularly;
- Chicken, fish, milk, meat or eggs can be eaten daily;
- Drink lots of clean, safe water;
- Eat plenty of vegetables and fruits every day;
- Use fats, salt and sugar sparingly;
- Be active,

(Department of Health, 2004)

Also see Part 5 of Nutrition Education Manual, Volume 1

2.1.5 Maintenance of garden and equipment

Clear rules must be set out regarding the following:

- How the garden should look like with regard to tidiness, demarcation, displaying of educational signs and opinions and involvement of the community,
- The maintenance and safe guarding of equipment, eg. where the equipment will be locked away and how to book out and return equipment,
- Learner involvement: how much time learners will spend in the garden, how will the school subjects be taught and incorporated to gardening sessions.

It must be stressed that the learners must always use equipment under supervision to avoid accidents.

2.1.6 Utilization of the produce

Where the harvest is good, all school staff will be happy to have a share of the food produced. However, you may want to establish some ground rules - for example, give needy learners first.

An important consideration of the garden is to decide on which days which crops to harvest to supply for the school meals, and how much of each crop is needed. The school menu can be adapted according to seasonal availability of the crops from the garden. The kitchen should be able to cook the produce from the garden at least once a week.

Cultivation of different crops in the garden must be continuous for at least 10 months of the year. Enough of each crop should be planted to obtain substantial quantities of the produce.

Ensure that enough funds are available to sustain the garden. Some of the vegetables, fruits and seedlings can be sold to generate income to sustain the garden. The pricing should be realistic to cover expenses but also market related to ensure good demand. Keeping accurate records of the sales is very important.

2.1.7 Garden portfolio

A garden portfolio should be maintained. This information will assist in budgeting, financial management, provision of adequate supplies and decision on plot sizes. The portfolio will further assist to showcase achievements of the garden to the sponsors.

THE SCHOOL GARDEN PORTFOLIO

1. **School details -** name of school, EMIS number, responsible educators, contact numbers, physical address, postal address.
2. **Nutrition committee/Support Network -** The main team that is responsible for initiating activities and making decisions on the school garden and their responsibilities. This section can include information on the role of other educators and the general community participation.
3. **General information on the project -** mission, vision, objectives, size of the garden, type of soil, method of irrigation, list of equipment (no need if it is in the school assets register)
4. **Curriculum integration schedule -** allocation of the class for gardening activities.
5. **Record keeping -** costs and returns, planting dates, harvest time, provision of vegetables for the school meals and others, selling , etc
6. **External support -** the government, business, NGO's, individuals and any sponsors, and summary of type of support provided to the school.
7. **Visuals - S**pecial achievements, garden milestones and photos.
8. **Visitors records -** external significant visitors

3. PLANNING

3.1 What is needed?

Commitment is the most important prerequisite, without which there is not much hope for success. Other important requirements are motivation, enthusiasm, organizational capacity and communication.







Three school garden skills

"You need to know only three things to run a successful school garden:

- How to cultivate people;
- How to cultivate plants; and
- Where to go for help".

3.1.1 Basic needs for a garden

- Proper fencing,
- Good quality water,
- Funds for buying inputs such as fertilizer, seeds /seedlings, pesticides and Garden tools,
- Supply and/or production of compost
- Sources of advice and support.

Gardening tools

Required basic equipment for a plot of 20 m x 20 m with 30 learners includes: 2 wheel barrows, 6 hoes, 2 spades, 3 watering cans,1 hose pipe (30 m long), 2 rakes, 2 buckets, 4 garden forks, 2 hand shovels, 1 knapsack sprayer, 30 m tape measure, stakes, sticks and string (FAO, 2005). Include 2 pruning shears if the school has fruit trees.

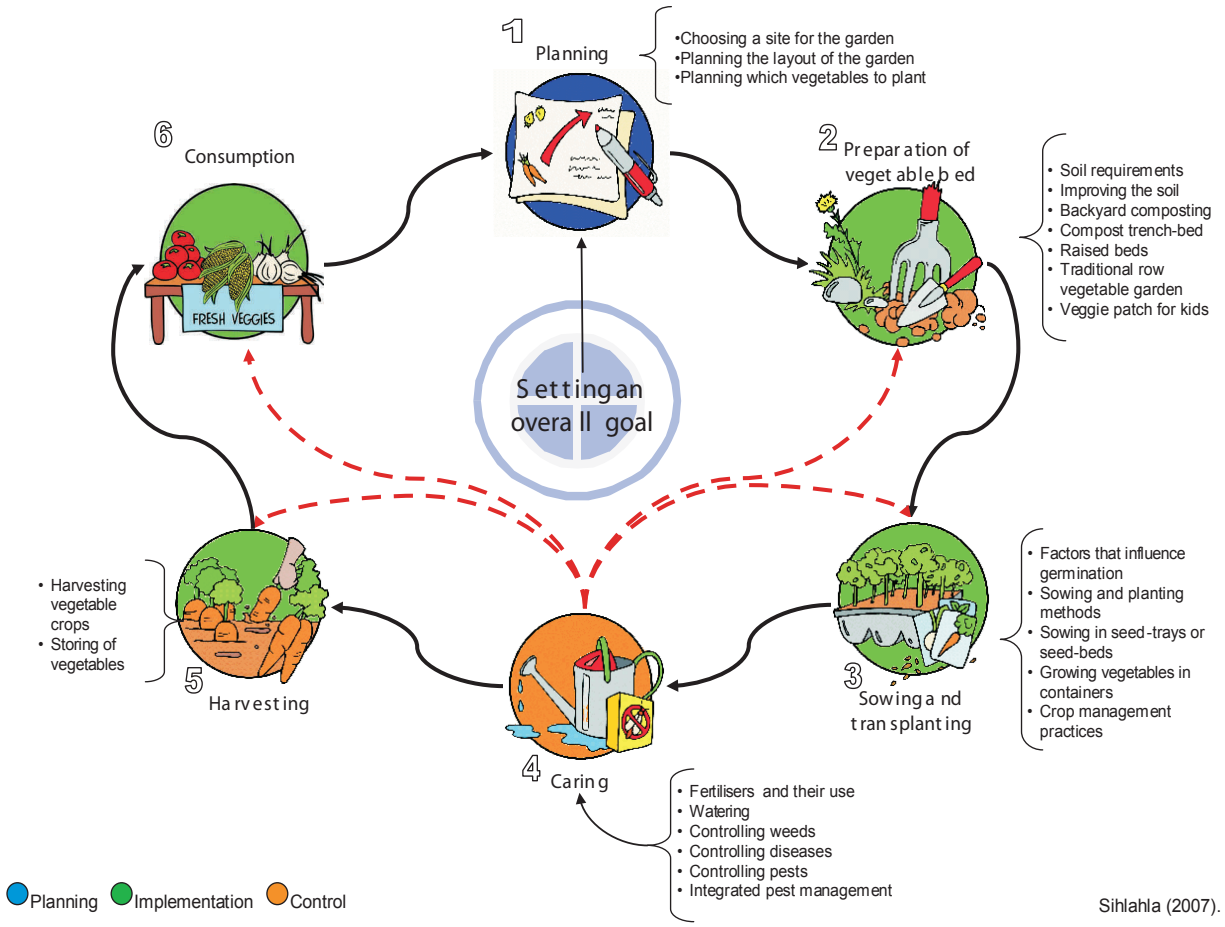
It is important to know more than one agricultural supplier in and around your area.

3.2 Planning for production

3.2.1 Factors to be considered

Planning is the first activity for the successful establishment of a garden. Planning ensures efficient utilization of resources, it optimizes returns and reduces losses.

The main aims in planning a food production unit are to keep it in production for as long as possible, and to produce enough of the needed vegetables/fruits. A critical period is when one season's crop is harvested and the next season's crop is planted. Careful planning is needed to avoid delays and consequent break in the supply of fresh produce.



Modified from Nell & Du Plessis (2005)

The most important aspects to consider when planning for production are:

- Climatic conditions;
- Water availability and quality;
- Soil type and suitability;
- Layout of the garden;
- Size and location of plots;
- Crop choice will be based on suitability and nutritional value of crops;
- Crop succession.

3.2.2 Layout of the garden

Make a sketch plan of the garden to scale, and divide it into workable units/plots. Give each unit a number for future reference.

- Separate perennial and annual vegetables/herbs and vegetables with long and short growing periods.
- Separate summer and winter vegetables.
- Leave space for varying planting dates for vegetables such as carrots, beet, spinach, beans, etc. to ensure continuity throughout the season.
- Provide space for fruit trees so that they can grow freely.
- Ensure ease of movement within the garden.

A summary of planting and harvesting times of various vegetable crops and their plant spacing, is provided in Table 3.2. This will be helpful when planning.

3.2.3 Reflection using Table 3.1 and 3.2

Onverwacht Primary is planning to plant an area of 5 m x 10 m, of which half will be planted with spinach and half with carrot.

Tell me:

1. Is carrot a cool or moderate or warm weather crop?
2. Which is the earliest month they can start planting carrot?
3. What area (m^2) will be planted with carrot?
4. How many grams of carrot seed will they need?
5. How many kilograms of carrot can they expect to harvest?

Table 3.1 Classification of horticultural crops according to temperature adaption (crops followed by "P" are priority crops on the NSNP menu)

Cool-season	Moderate-season	Warm-season
Vegetables		
Beetroot[P]	Amaranthus	Amadumbi
Broccoli	Bean[P]	Amaranthus, ALV's *
Brussels sprout	Carrot[P]	Bambara
Cabbage[P]	Cleome	Green bean[P]
Cauliflower	Onion[P]	Cowpea
Celery	Parsley	Cucumber
Chinese cabbage	Potato[P]	Eggplant
Leek	Tomato[P]	Green mealie
Lettuce		Melon
Onion[P]		Pepper
Pea		Pigeon pea
Radish		Pumpkin[P]
Swiss chard[P]		Butternut squash[P]
Turnip		Sweet potato
		Tomato[P]
		Watermelon
Herbs		
Garlic	Rosemary	Origanum
Parsley		Basil
Parsnip		Thyme
Fruit		
Peach	Citrus	Banana
Apricot	Granadilla	Papaya
Fig		Mango

* ALV's = African Leafy Vegetables e.g. corchorus, cleome, kale

Table 3.2. Summarized information on vegetable crops to assist in optimal planning and production.

CROP	Soil pH	Months for planting/ sowing	Planting Method	Seed needed (g/100 m²)	Plant spacing (cm)		Nr of plants per 100 m²	Time to harvesting (days)	Months for harvesting	Obtainable yield (kg/100 m²)
					Between plants	Between rows				
Amadumbi	5.5-6.5	Aug-Oct	direct planting	330-550 corms	30-60	60-100	330-550	160-225	Jun Sep	200
Amaranth	5.5-7.5	Aug-Oct	transplanting	5-15	8-15	20-30	2220- 6300	60-180	Sep-Mar	300
ALV's	5.5-7.5	Oct-Dec	direct sowing	10-50	10-15	25-35	2000-4000	100-150	Nov-Mar	25
Bean (bush)	6.0-6.5	Feb-Mar, Aug-Oct	direct sowing	750-1200	5-10	40-60	1500-5000	60-90	May-Jun, Oct-Dec	100
Beetroot	5.8-7.5	Feb-Apr, Aug-Sep	direct sowing	60-80	8-15	30-45	1500-3400	90-105	Apr-Jun; Nov-Jan	200
Cabbage	6.0-7.0	Feb-Apr, Aug-Sep	transplanting	5-15	35-50	50-70	300-500	80-120	Jun-Jul; Nov-Dec	300
Carrot	6.0-6.5	Feb-Mar, Aug-Sep	direct sowing	25-35	5-7	30-40	3600-6700	80-120	May-Jul, Nov-Feb	250
Cucumber	6.0-6.8	Jan-Mar, Jul-Sep	direct sowing	20	50	120-150	130-170	60-100	Mar-Jun, Sep-Dec	300
Green mealies	5.5-6.8	Sep-Nov	direct sowing	100-150	30	100-120	300-500	90-120	Dec-Feb	100
Lettuce	6.5-7.0	Feb-May	transplanting	15-30	30	40-60	560-830	84-105	May-Sep	250
Onion	6.0-7.0	Mar-Apr	transplanting	30-50	5-8	20-25	5000-7000	90-180	Aug-Dec	300
Pepper	5.5-7.0	Aug-Oct, Jan-Feb	transplanting	10	40-60	75-100	170-330	100-150	Nov-Jun, Apr-May	240
Potato	5.0-6.5	Aug-Nov	direct planting	400-600tubers	25	75-100	400-570	90-140	Mar-May	300
Pumpkin	5.5-7.5	Aug-Nov	direct sowing	25-35	50-90	200-270	40-100	120-150	Jan-May	300
Spinach	6.0-6.5	Feb-Apr, Aug-Oct	transplant/direct	80	15-25	40-60	700-1700	40-120	Apr-Jun, Sep-Jan	100
Sweet potato	5.6-6.5	Oct-Jan	direct planting	330-600 cuttings	30	80-120	280-440	120-150	Mar-Jul	30
Tomato	6.0-6.5	Aug-Nov	Transplanting	5-10	40-50	150	130-170	100-145	Jan-Apr	30

* ALV's = African Leafy Vegetables e.g. corchorus, cleome, kale

3.3.Nutritional information on fruits and vegetables

3.3.1 Menus for National School Nutrition Programme

The school nutrition programme provides one meal per day to learners. This consists of a cooked protein, starch as well as fresh fruit or vegetable. Fruits and vegetables are included to provide vitamins and minerals which are lacking in most children's diet.

The NSNP recipe book 'Mnandi4Sure' specifies recommended provincial menus and the type of vegetable and fruit which can be included. A list of vegetables that can be produced on large scale for the NSNP include beetroot, butternut, cabbage, carrot, greenbeans, pumpkin and spinach. Green and orange vegetables are alternated on the menu to ensure a variety and to benefit from better quality of fresh produce. NSNP recommended portion size for vegetable is 60 g (½ cup) per learner or one medium size fruit e.g. apple, banana or orange.

The protein vegetables such as lentil, soya bean and split pea, which are included in the menus, can be cooked with the onions, peppers, tomatoes and herbs to enhance flavour. However, they must not be used as a substitute for protein item.

(a)Dietary fibre

Dietary fiber, also known as roughage includes all parts of plant foods that your body cannot digest or absorb.It is found mainly in fruits, vegetables, whole grains and legumes. The main constituent of fibre is cellulose, apolysaccharide (carbohydrate) which is the structural component of plant tissues. Cellulose is not broken down in the human digestive system (but can be broken down by bacteria in the guts of some mammals).It passes relatively intact through your stomach, small intestine, colon and out of your body.

Functions of fibre in the diet

- It is helps with digestion and prevents or relieves constipation
- It lowers blood sugar levels (or the risk of diabetes)
- It lowers the risk of heart disease
- It aids in weight loss: It tends to make a meal more bulky and linger

(b)Minerals and vitamins

These micronutrients are required by the body in fairly small quantities. Minerals are absorbed by plants from the soil and most of them are also essential plant nutrients. Vitamins and other organic molecules are synthesized during various metabolic processes in plants from simple inorganic compounds. Micronutrients are present in plant tissues at varying amounts.

Table3.3 Outlines the functions of vitamins and minerals in the human body, the main food sources and the deficiency symptoms

Vitamin	Functions in the body	Main food sources	Deficiency symptoms
B1 (thiamin)	Supports energy metabolism and nerve function	Spinach, greenpea, tomato juice, watermelon, pork chop, soymilk, margarine	Regular fatigue, weakness and dysfunctional nervous system
B2 (riboflavin)	Supports energy metabolism, normal vision and skin health	Spinach, broccoli, mushroom, egg, milk, liver, oyster, clam	Inflammation of skin, sores and lesions in the mouth
B3 (niacin)	Supports energy metabolism, skin health, nervous system and digestive system	Spinach, potato, tomato, lean beef, chicken, tuna, liver, shrimp	Diarrhea, vomiting, inflammation of the tongue, poor memory
B6 (pyridoxine	Amino acid and fatty acid metabolism, red blood cell production	Banana, watermelon, tomato, broccoli, spinach, potato, white rice, chicken breast	Dizziness, nausea, confusion, irritability and convulsions.
Folate	Supports DNA synthesis and new cell formation	Tomato, greenbean, broccoli, spinach, asparagus, okra, black-eyed pea, lentil	Anemia, mental fatigue, headache
B12	Used in new cell synthesis, helps break down fatty acids and amino acids, supports nerve cell maintenance	Poultry, fish, milk, egg	Loss of appetite, anemia, fatigue, sore tongue
C (ascorbic acid)	Collagen synthesis, amino acid metabolism, helps iron absorption, immunity	Spinach, broccoli, red pepper, snowpea, tomato juice, kiwi, mango, orange, grapefruit juice, strawberry	Scurvy, poor wound healing, impaired immunity
A (retinol)	Supports vision, skin, bone and tooth growth, immunity and reproduction	Mango, broccoli, butternut squash, carrot, tomato juice, sweet potato, pumpkin, beef liver	Night blindness, dry skin, poor growth, and weak tooth enamel.
D	Promotes bone mineralization	Self-synthesis via sunlight, fortified milk, egg yolk, liver, fish	Rickets, osteomalacia
E	Antioxidant, regulation of oxidation reactions, supports cell membrane stabilization	Polyunsaturated plant oils (soybean, corn and canola oils),wheat, margarine, avocado, sweet potato, shrimp	Deficiency is rare in humans

Mineral	What the mineral does	Significant food sources	Deficiencies
Sodium	Maintains fluid and electrolyte balance, supports muscle contraction and nerve impulse transmissions	Salt, soysauce, bread, milk, meat,	Deficiency is rare in humans
Chloride	Maintains fluid and electrolyte balance, aids in digestion	Salt, soysauce, milk, egg, meat	Deficiency is rare in humans
Potassium	Maintains fluid and electrolyte balance, cell integrity, muscle contractions and nerve impulse transmission	Potatoes, acorn squash, spinach, broccoli, carrot, greenbean, tomato juice, avocado, grapefruit juice, watermelon, banana, strawberry, cod, milk	Muscular cramps, twitching and weakness, irregular heart beat, insomnia, kidney and lung failure
Calcium	Formation of bones and teeth, supports blood clotting	Milk, yoghurt, cheese, sardine, greenbean, spinach, broccoli	Weak bones and teeth, improper muscle contractions, poor blood clotting
Phosphorus	Formation of cells, bones and teeth, maintains acid- base balance	All animal foods (meat, fish, poultry, egg, milk)	Muscular weakness and painful limbs. Deficiency is rare in humans
Magnesium	Supports bone mineralization, protein building, muscular contraction, nerve impulse transmission, immunity	Spinach, broccoli, artichoke, green bean, tomato, black-eyed pea, sunflower seed, cashew nut	Fatigue, nervousness, insomnia, heart problems, high blood pressure, osteoporosis, muscle weakness and cramps
Iron	A constituent of hemoglobin which carries oxygen throughout body's cells	Parsley, spinach, broccoli, green bean, tomato, beef liver	Anemia, weakness, fatigue and impaired immunity
Zinc	A constituent of many enzymes, involved in DNA synthesis and proteins, metabolism of vitamin A, taste perception, wound healing, sperm production, normal development of the	Spinach, broccoli, green pea, greenbean, tomato, lentil, oyster, shrimp, turkey, leanham, lean beef, yogurt, cheese	Severe deficiency can contribute to stunted growth
Selenium	Antioxidant. Works with vitamin E to protect body from oxidation	Seafood, meat and grains	Selenium deficiency is rare in humans

Mineral	What the mineral does	Main food sources	Deficiencies
Iodine	Component of thyroid hormones that help regulate growth, development and metabolic rate	Salt, seafood, bread, milk, cheese	Hypothyroidism, goiter and retarded growth
Copper	Necessary for the absorption and utilization of iron, supports formation of hemoglobin and several enzymes	Seafood, meat, nuts, whole grains, fruit and vegetables	Anemia, weakness and fatigue
Manganese	Facilitates many cell processes	Widespread in foods	Deficiency is rare in humans
Fluoride	Involved in the formation of bones and teeth, helps to make teeth resistant to decay	Fluoridated drinking water, tea, seafood	Weak bones, tooth decay
Chromium	Associated with insulin and is required for the release of energy from glucose	Vegetable oils, liver, brewer's yeast, whole grains, cheese, nuts	Deficiency is rare in humans
Molybdenum	Facilitates many cell processes	Legume, meat, fruit	Deficiency is rare in humans

Table 3.4 The main vitamins and minerals found in common vegetables and the approximate quantity (mg) of the specified amount. Other vitamins and minerals are also present in small amounts

Vegetable	Amount	Minerals Contained	Vitamins Contained
Amaranth leaves 	One cup of amaranth leaves, cooked, boiled, drained with no added salt has 2.79 grams protein and 28 calories.	Potassium - 846 mg Phosphorus - 95 mg Magnesium - 73 mg Calcium - 276 mg Iron - 2.98 mg Zinc - 1.16 mg Manganese - 1.137 mg Sodium - 28 mg Copper - 0.209 mg Selenium - 1.2 µg	Vitamin A - 3656 IU Vitamin C - 54.3 mg Vitamin B1 - 0.026 mg Vitamin B2 - 0.177 mg Niacin - 0.738 mg Pantothenic Acid - 0.082 mg Vitamin B6 - 0.234 mg Folate - 75 µg
Beetroot 	One half cup of beets, cooked, boiled, drained, without salt contains 1.43 grams protein, 37 calories and 1.7 grams dietary fiber.	Potassium - 259 mg Phosphorus - 32 mg Magnesium - 20 mg Calcium - 14 mg Iron - 0.67 mg Sodium - 65 mg Zinc - 0.3 mg Copper - 0.063 mg Manganese - 0.277 mg Selenium - 0.6 µg	Vitamin C - 3.1 mg Niacin - 0.281 mg Folate - 68 µg Vitamin B1 - 0.023 mg Vitamin B2 - 0.034 mg Pantothenic Acid - 0.123 mg Vitamin B6 - 0.057 mg Vitamin A - 30 IU Vitamin K - 0.2 µg Vitamin E - 0.03 mg
Butternut 	One cup of Butternut squash, cooked, baked, drained with no added salt has 1.84 grams protein and 82 calories.	Potassium - 582 mg Phosphorus - 55 mg Magnesium - 59 mg Calcium - 84 mg Iron - 1.23 mg Zinc - 0.27 mg Copper - 0.133 mg Manganese - 0.353 mg Selenium - 1 µg Sodium - 8 mg	Vitamin C - 31 mg Niacin - 1.986 mg Vitamin B1 - 0.148 mg Vitamin B2 - 0.035 mg Pantothenic Acid - 0.736 mg Vitamin B6 - 0.254 mg Folate - 39 µg Vitamin A - 22868 IU Vitamin K - 2 µg Vitamin E - 2.64 mg
Cabbage 	One half cup of cabbage, cooked, boiled, drained with no added salt has 0.95 grams protein, 17 calories and 1.4 grams of dietary fiber.	Potassium - 147 mg Phosphorus - 25 mg Magnesium - 11 mg Calcium - 36 mg Iron - 0.13 mg Sodium - 6 mg Zinc - 0.15 mg Copper - 0.013 mg Manganese - 0.154 mg Selenium - 0.5 µg	Vitamin C - 28.1 mg Niacin - 0.186 mg Vitamin B1 - 0.046 mg Vitamin B2 - 0.029 mg Vitamin B6 - 0.084 mg Folate - 22 µg Pantothenic Acid - 0.13 mg Vitamin A - 60 IU Vitamin K - 81.5 µg Vitamin E - 0.11 mg

Vegetable	Amount	Minerals Contained	Vitamins Contained
Mushroom 	Half a cup of raw mushrooms contains 1.08 grams of protein, 8 calories and 0.3 grams of fiber.	Potassium - 111 mg Phosphorus - 30 mg Magnesium - 3 mg Calcium - 1 mg Iron - 0.17 mg Sodium - 2 mg Zinc - 0.18 mg Copper - 0.111 mg Manganese - 0.016 mg Selenium - 3.3 µg	Vitamin D - 2 IU Niacin - 1.262 mg Vitamin B1 - 0.028 mg Vitamin B2 - 0.141 mg Vitamin B6 - 0.036 mg Vitamin C - 0.7 mg Pantothenic Acid - 0.524 mg Folate - 6 µg
Onion 	One small onion cooked without salt contains 0.82 grams protein, 26 calories and 0.8 grams of fiber.	Potassium - 100 mg Phosphorus - 21 mg Calcium - 13 mg Iron - 0.14 mg Magnesium - 7 mg Sodium - 2 mg Zinc - 0.13 mg Copper - 0.04 mg Manganese - 0.092 mg Selenium - 0.4 µg	Vitamin C - 3.1 mg Niacin - 0.099 mg Vitamin B1 - 0.025 mg Vitamin B2 - 0.014 mg Vitamin B6 - 0.077 mg Pantothenic Acid - 0.068 mg Folate - 9 µg Vitamin A - 1 IU Vitamin K - 0.3 µg Vitamin E - 0.01 mg
Pea 	One cup of boiled peas with no salt added contains 8.58 grams of protein, 134 calories and 8.8 grams of fiber.	Potassium - 434 mg Phosphorus - 187 mg Magnesium - 62 mg Calcium - 43 mg Sodium - 5 mg Selenium - 3.0 mg Iron - 2.46 mg Zinc - 1.9 mg Manganese - 0.84 mg Copper - 0.277 mg	Vitamin A - 1282 IU Vitamin C - 22.7 mg Niacin - 3.234 mg Folate - 101 µg Vitamin B1 - 0.414 mg Vitamin B2 - 0.238 mg Vitamin B6 - 0.346 mg Pantothenic Acid - 0.245 mg Vitamin K - 41.4 µg Vitamin E - 0.22 mg
Potato 	One medium baked potato without salt contains 4.33 grams of protein, 161 calories and 3.8 grams of fiber.	Potassium - 926 mg Phosphorus - 121 mg Magnesium - 48 mg Calcium - 26 mg Iron - 1.87 mg Sodium - 17 mg Zinc - 0.62 mg Copper - 0.204 mg Manganese - 0.379 mg Selenium - 0.7 µg	Vitamin C - 16.6 mg Niacin - 2.439 mg Vitamin B1 (thiamine) - 0.111 mg Vitamin B2 (riboflavin) - 0.083 mg Pantothenic Acid - 0.65 mg Vitamin B6 - 0.538 mg Folate - 48 µg Vitamin A - 17 IU Vitamin K - 3.5 µg Vitamin E - 0.07 mg

Vegetable	Amount	Minerals Contained	Vitamins Contained
Carrots 	One cup cooked with no added salt contains 0.59 grams protein, 27 calories and 2.3 grams fiber.	Potassium - 366 mg Calcium - 46 mg Phosphorus - 46 mg Magnesium - 16 mg Iron - 0.54 mg Sodium – 0.98 mg Zinc - 0.6 mg Copper - 0.1 mg Manganese - 0.12 mg Selenium - 0.4 µg	Vitamin C – 5.6 mg Vitamin B1 - 0.1 mg Vitamin B2 - 0.064 mg Niacin – 1.13 mg Folate - 11 µg Pantothenic Acid - 0.181 mg Vitamin B6 - 0.22 mg Vitamin A - 26562 IU Vitamin K - 20.7 µg Vitamin E – 1.8 mg
French beans 	One cup of French beans, mature seeds, cooked, boiled with no added salt has 12.48 grams protein, 228 calories and 16.6 grams of dietary fiber.	Potassium - 655 mg Phosphorus - 181 mg Magnesium - 99 mg Calcium - 112 mg Iron - 1.91 mg Sodium - 11 mg Zinc - 1.13 mg Copper - 0.204 mg Manganese - 0.676 mg Selenium - 2.1 µg	Vitamin C - 2.1 mg Niacin - 0.966 mg Vitamin B1 - 0.23 mg Vitamin B2 - 0.11 mg Vitamin B6 - 0.186 mg Folate - 133 µg Pantothenic Acid - 0.393 mg Vitamin A - 5 IU
Green mealie 	One large ear of yellow corn, cooked with no salt contains 4.02 grams protein, 113 calories and 2.8 grams fiber.	Potassium - 257 mg Phosphorus - 91 mg Magnesium - 31 mg Calcium - 4 mg Selenium - 0.2 mg Iron - 0.53 mg Zinc - 0.73 mg Copper - 0.058 mg Manganese - 0.197 mg	Vitamin C - 6.5 mg Niacin - 1.986 mg Vitamin B1 - 0.11 mg Vitamin B2 - 0.067 mg Vitamin B6 - 0.164 mg Folate - 27 µg Pantothenic Acid - 0.935 mg Vitamin A - 310 IU Vitamin K - 0.5 µg Vitamin E - 0.11 mg
Green Pepper 	One small raw pepper contains 0.64 grams protein, 15 calories and 1.3 grams fiber.	Potassium - 130 mg Phosphorus - 15 mg Magnesium - 7 mg Calcium - 7 mg Iron - 0.25 mg Sodium - 2 mg Zinc - 0.1 mg Copper - 0.049 mg Manganese - 0.09 mg	Vitamin C - 59.5 mg Niacin - 0.355 mg Vitamin B1 - 0.042 mg Vitamin B2 - 0.021 mg Vitamin B6 - 0.166 mg Folate - 7 µg Pantothenic Acid - 0.073 mg Vitamin A - 274 IU Vitamin K - 5.5 µg Vitamin E - 0.27 mg

Vegetable	Amount	Minerals Contained	Vitamins Contained
Pumpkin 	One cup of pumpkin, cooked, boiled, drained, with no added salt has 1.76 grams protein, 49 calories and 2.7 grams of dietary fiber.	Potassium - 564 mg Phosphorus - 74 mg Magnesium - 22 mg Calcium - 37 mg Iron - 1.4 mg Sodium - 2 mg Zinc - 0.56 mg Copper - 0.223 mg Manganese - 0.218 mg Selenium - 0.5 µg	Vitamin C - 11.5 mg Niacin - 1.012 mg Vitamin B1 (thiamine) - 0.076 mg Vitamin B2 (riboflavin) - 0.191 mg Vitamin B6 - 0.108 mg Folate - 22 µg Pantothenic Acid - 0.492 mg Vitamin A - 12230 IU Vitamin K - 2 µg Vitamin E - 1.96 mg
Sweet Potato 	One medium sweet potato baked in its skin contains 2.29 grams of protein, 103 calories and 3.8 grams of fiber.	Potassium - 542 mg Phosphorus - 62 mg Magnesium - 31 mg Calcium - 43 mg Sodium - 41 mg Iron - 0.79 mg Selenium - 0.2 mg Manganese - 0.567 mg Zinc - 0.36 mg Copper - 0.184 mg	Vitamin C - 22.3 mg Niacin - 1.695 mg Vitamin B1 - 0.122 mg Vitamin B2 - 0.121 mg Vitamin B6 - 0.326 mg Pantothenic Acid - 1.008 mg Folate - 7 µg Vitamin A - 21,909 mg Vitamin K - 2.6 µg Vitamin E - 0.81 mg
Swiss chard (Spinach) 	One cup of Swiss chard, cooked, boiled, drained, has 3.29 grams protein, 35 calories and 3.7 grams of dietary fiber.	Potassium - 961 mg Phosphorus - 58 mg Magnesium - 150 mg Calcium - 102 mg Iron - 3.95 mg Sodium - 313 mg Zinc - 0.58 mg Copper - 0.285 mg Manganese - 0.585 mg Selenium - 1.6 µg	Vitamin C - 31.5 mg Niacin - 0.63 mg Vitamin B1 - 0.06 mg Vitamin B2 - 0.15 mg Vitamin B6 - 0.149 mg Pantothenic Acid - 0.285 mg Folate - 16 µg Vitamin A - 10717 IU Vitamin K - 572.8 µg Vitamin E - 3.31 mg
Tomato 	One medium tomato contains 1.08 grams of protein, 22 calories and 1.5 grams of fiber.	Potassium - 292 mg Phosphorus - 30 mg Magnesium - 14 mg Calcium - 12 mg Sodium - 6 mg Iron - 0.33 mg Manganese - 0.14 mg Copper - 0.073 mg Zinc - 0.21 mg	Vitamin A - 1025 IU Vitamin B1 - 0.046 mg Vitamin B2 - 0.023 mg Niacin - 0.731 mg Folate - 18 µg Pantothenic Acid - 0.109 mg Vitamin B6 - 0.098 mg Vitamin C - 15.6 mg Vitamin E - 0.66 mg Vitamin K - 9.7 µg

Table 3.5 The main nutritional content of common fruits. The fruit also contain small amounts of other vitamins and minerals

Fruit	Amount	Minerals Contained	Vitamins Contained
Apple 	One medium apple with skin contains 0.47 grams of protein, 95 calories, and 4.4 grams of dietary fiber.	Potassium - 195 mg Calcium - 11 mg Phosphorus - 20 mg Magnesium - 9 mg Manganese - 0.064 mg Iron - 0.22 mg Sodium - 2 mg Copper - 0.049 mg Zinc - 0.07 mg .	Vitamin A - 98 IU Vitamin B1 - 0.031 mg Vitamin B2 - 0.047 mg Niacin - 0.166 mg Folate - 5 µg Pantothenic Acid - 0.111 mg Vitamin B6 - 0.075 mg Vitamin C - 8.4 mg Vitamin E - 0.33 mg Vitamin K - 4 µg
Avocado 	One medium avocado contains 4.02 grams of protein, 322 calories and 13.5 grams of fiber.	Potassium - 975 mg Phosphorus - 105 mg Magnesium - 58 mg Calcium - 24 mg Sodium - 14 mg Iron - 1.11 mg Selenium 0.8 µg Manganese - 0.285 mg Copper - 0.382 mg Zinc - 1.29 mg .	Vitamin A - 293 IU Vitamin C - 20.1 mg Vitamin B1 - 0.135 mg Vitamin B2 - 0.261 mg Niacin - 3.493 mg Folate - 163 µg Pantothenic Acid - 2.792 mg Vitamin B6 - 0.517 mg Vitamin E - 4.16 mg Vitamin K - 42.2 µg
Banana 	One medium banana contains 1.29 grams of protein, 105 calories and 3.1 grams of dietary fiber.	Potassium - 422 mg Phosphorus - 26 mg Magnesium - 32 mg Calcium - 6 mg Sodium - 1 mg Iron - 0.31 mg Selenium 1.2 µg Manganese - 0.319 mg Copper - 0.092 mg Zinc - 0.18 mg	Vitamin A - 76 IU Vitamin B1 - 0.037 mg Vitamin B2 - 0.086 mg Niacin - 0.785 mg Folate - 24 µg Pantothenic Acid - 0.394 mg Vitamin B6 - 0.433 mg Vitamin C - 10.3 mg Vitamin E - 0.12 mg Vitamin K - 0.6 µg
Fig 	One large, fresh fig contains 0.48 grams of protein, 47 calories and 1.9 grams of dietary fiber.	Potassium - 148 mg Phosphorus - 9 mg Magnesium - 11 mg Calcium - 22 mg Sodium - 1 mg Iron - 0.24 mg Selenium 0.1 µg Manganese - 0.082 mg Copper - 0.045 mg Zinc - 0.1 mg	Vitamin A - 91 IU Vitamin B1 - 0.038 mg Vitamin B2 - 0.032 mg Niacin - 0.256 mg Folate - 4 µg Pantothenic Acid - 0.192 mg Vitamin B6 - 0.072 mg Vitamin C - 1.3 mg Vitamin E - 0.07 mg Vitamin K - 3 µg

Fruit	Amount	Minerals Contained	Vitamins Contained
Granadilla 	One cup of fresh passion fruit contains 5.19 grams of protein, 229 calories and 24.5 grams of dietary fiber.	Potassium - 821 mg Phosphorus - 160 mg Magnesium - 68 mg Calcium - 28 mg Sodium - 66 mg Iron - 3.78 mg Selenium 1.4 µg Copper - 0.203 mg Zinc - 0.24 mg	Vitamin A - 3002 IU Vitamin B2 - 0.307 mg Niacin - 3.54 mg Folate - 33 µg Vitamin B6 - 0.236 mg Vitamin C - 70.8 mg Vitamin E - 0.05 mg Vitamin K - 1.7 µg
Guava 	One cup of fresh guava contains 4.21 grams of protein, 112 calories and 8.9 grams of dietary fiber.	Potassium - 688 mg Phosphorus - 66 mg Magnesium - 36 mg Calcium - 30 mg Sodium - 3 mg Iron - 0.43 mg Selenium 1 µg Manganese - 0.247 mg Copper - 0.38 mg Zinc - 0.38 mg	Vitamin A - 1030 IU Vitamin B1 - 0.111 mg Vitamin B2 - 0.066 mg Niacin - 1.789 mg Folate - 81 µg Pantothenic Acid - 0.744 mg Vitamin B6 - 0.181 mg Vitamin C - 376.7 mg Vitamin E - 1.2 mg Vitamin K - 4.3 µg
Mango 	One mango without peel contains 1.06 grams of protein, 135 calories and 3.7 grams of dietary fiber.	Potassium - 323 mg Phosphorus - 23 mg Magnesium - 19 mg Calcium - 21 mg Sodium - 4 mg Iron - 0.27 mg Selenium 1.2 µg Manganese - 0.056 mg Copper - 0.228 mg Zinc - 0.08 mg	Vitamin A - 1584 IU Vitamin B1 - 0.12 mg Vitamin B2 - 0.118 mg Niacin - 1.209 mg Folate - 29 µg Pantothenic Acid - 0.331 mg Vitamin B6 - 0.227 mg Vitamin C - 57.3 mg Vitamin E - 2.32 mg Vitamin K - 8.7
Nectarine 	One cup of sliced fresh nectarine contains 1.52 grams of protein, 63 calories and 2.4 grams of dietary fiber.	Potassium - 287 mg Phosphorus - 37 mg Magnesium - 13 mg Calcium - 9 mg Iron - 0.4 mg Manganese - 0.077 mg Copper - 0.123 mg Zinc - 0.24 mg	Vitamin A - 475 IU Vitamin B1 - 0.049 mg Vitamin B2 - 0.039 mg Niacin - 1.609 mg Folate - 7 µg Pantothenic Acid - 0.265 mg Vitamin B6 - 0.036 mg Vitamin C - 7.7 mg Vitamin E - 1.1 mg Vitamin K - 3.1 µg

Fruit	Amount	Minerals Contained	Vitamins Contained
Orange 	One medium orange contains 1.23 grams of protein, 62 calories and 3.1 grams of dietary fiber.	Potassium - 237 mg Phosphorus - 18 mg Magnesium - 13 mg Calcium - 52 mg Iron - 0.13 mg Selenium 0.7 µg Manganese - 0.033 mg Copper - 0.059 mg Zinc - 0.09 mg	Vitamin A - 295 IU Vitamin B1 - 0.114 mg Vitamin B2 - 0.052 mg Niacin - 0.369 mg Folate - 39 µg Pantothenic Acid - 0.328 mg Vitamin B6 - 0.079 mg Vitamin C - 69.7 mg Vitamin E - 0.24 mg
Papaya 	One cup of cubed fresh papaya contains 0.85 grams of protein, 55 calories and 2.5 grams of dietary fiber.	Potassium - 360 mg Phosphorus - 7 mg Magnesium - 14 mg Calcium - 34 mg Sodium - 4 mg Iron - 0.14 mg Selenium 0.8 µg Zinc - 0.1 mg Manganese - 0.015 mg Copper - 0.022 mg	Vitamin A - 1532 IU Vitamin B1 - 0.038 mg Vitamin B2 - 0.045 mg Niacin - 0.473 mg Folate - 53 µg Pantothenic Acid - 0.305 mg Vitamin B6 - 0.027 mg Vitamin C - 86.5 mg Vitamin E - 1.02 mg Vitamin K - 3.6 µg
Peach 	One medium peach contains 1.36 grams of protein, 58 calories and 2.2 grams dietary fiber.	Potassium - 285 mg Phosphorus - 30 mg Magnesium - 14 mg Calcium - 9 mg Iron - 0.38 mg Selenium 0.1 µg Manganese - 0.091 mg Copper - 0.102 mg Zinc - 0.26 mg	Vitamin A - 489 IU Vitamin B1 - 0.036 mg Vitamin B2 - 0.047 mg Niacin - 1.209 mg Folate - 6 µg Pantothenic Acid - 0.229 mg Vitamin B6 - 0.037 mg Vitamin C - 9.9 mg Vitamin E - 1.09 mg Vitamin K - 3.9 µg
Pear 	One medium pear contains 0.68 grams of protein, 103 calories and 5.5 grams dietary fiber.	Potassium - 212 mg Phosphorus - 20 mg Magnesium - 12 mg Calcium -16 mg Sodium - 2 mg Iron - 0.3 mg Selenium 0.2 µg Manganese - 0.087 mg Copper - 0.146 mg Zinc - 0.18 mg	Vitamin A - 41 IU Vitamin B1 - 0.021 mg Vitamin B2 - 0.045 mg Niacin - 0.279 mg Folate - 12 µg Pantothenic Acid - 0.085 mg Vitamin B6 - 0.05 mg Vitamin C - 7.5 mg Vitamin E - 0.21 mg Vitamin K - 8 µg

Fruit	Amount	Minerals Contained	Vitamins Contained
Pineapple 	One cup of fresh pineapple chunks contains 0.89 grams of protein, 82 calories and 2.3 grams of dietary fiber.	Potassium - 180 mg Phosphorus - 13 mg Magnesium - 20 mg Calcium -21 mg Sodium - 2 mg Iron - 0.48 mg Selenium 0.2 µg Manganese - 1.53 mg Copper - 0.181 mg Zinc - 0.2 mg	Vitamin A - 96 IU Vitamin B1 - 0.13 mg Vitamin B2 - 0.053 mg Niacin - 0.825 mg Folate - 30 µg Pantothenic Acid - 0.351 mg Vitamin B6 - 0.185 mg Vitamin C - 78.9 mg Vitamin E - 0.03 mg Vitamin K - 1.2 µg
Plum 	One cup of sliced, fresh plums contains 1.15 grams of protein, 76 calories and 2.3 grams dietary fiber.	Potassium - 259 mg Phosphorus - 26 mg Magnesium - 12 mg Calcium - 10 mg Iron - 0.28 mg Manganese - 0.086 mg Copper - 0.094 mg Zinc - 0.17 mg	Vitamin A - 569 IU Vitamin B1 - 0.046 mg Vitamin B2 - 0.043 mg Niacin - 0.688 mg Folate - 8 µg Pantothenic Acid - 0.223 mg Vitamin B6 - 0.048 mg Vitamin C - 15.7 mg Vitamin E - 0.43 mg Vitamin K - 10.6 µg
Watermelon 	I medium wedge (slice) of watermelon (about 2 cups edible portion) contains 1.74 grams of protein, 86 calories and 1.1 grams of dietary fiber.	Potassium - 320 mg Phosphorus - 31 mg Magnesium - 29 mg Calcium - 20 mg Sodium - 3 mg Iron - 0.69 mg Selenium 1.1 µg Manganese - 0.109 mg Copper - 0.12 mg Zinc - 0.29 mg	Vitamin A - 1627 IU Vitamin B1 - 0.094 mg Vitamin B2 - 0.06 mg Niacin - 0.509 mg Folate - 9 µg Pantothenic Acid - 0.632 mg Vitamin B6 - 0.129 mg Vitamin C - 23.2 mg Vitamin E - 0.14 mg Vitamin K - 0.3 µg

Note:
In the metric system, a microgram (µg or mcg) is a unit of mass equal to 1/1,000,000 of a gram (1 × 10^{-6} x 1g), or 1/1000 of a milligram. It is one of the smallest units of mass commonly used. The abbreviation µg conforms to the International System of Units and is often used in scientific literature.

Source: Combating Malnutrition in South Africa: Input paper for Health Roadmap, September 2008.www.healthalternatives2000.com/vegetables-nutrition-chart.html

4. AGRICULTURAL SYSTEMS FOR VEGETABLES

In part 4 various aspects relevant to growing vegetables are discussed and options are given to identify the best method for your garden. The aim is to optimize production through proper utilization of resources, taking into account the main purpose of teaching learners food production skills and good nutrition.

4.1 Soil properties

Before developing new areas for planting, a soil survey should be done to identify the best suitable sites for planting. The agricultural extension office, Department of Agriculture, in your area should have soil maps of the region indicating soil properties and soil fertility.

4.1.1 Soil texture

Soil texture determines:

- Cultivation and irrigation methods.
- The amount of the water that can be stored in the soil.
- The amount of nutrients available for the plant.
- Type of fertilizers to be applied.
- Suitability of the soil for growing specific crops

Soil can be analyzed in a soil testing laboratory to determine the texture, or by means of a field test.

A Field test to determine soil type:
Put two hands of soil in a container and add a small amount of water. Rub the wet soil between your fingers. How does it feel?

Gritty or course? If so, then it contains sand or gravel. If the gritty particles are very small and hard to see then it is sand. If the particles are bigger and more like small pebbles, then it is gravel. Sandy or gravelly soil does not hold water well; it is free - draining. When it rains the water passes through to the deeper layers of the soil quickly and become unavailable to plants. Sandy soil cannot hold nutrients well because they are easily washed away. Adding organic matter such as compost, leaves and old manure mixed with straws will enable sandy soil to hold more water and nutrients.

Soapy or slimy? If so, this is likely to be silt or loam soil. Loam soil holds water fairly well but does not have enough air spaces. Adding coarse organic matter such as mature compost and mature animal manure mixed with straws will improve the soil structure.

Sticky? If so, this is likely to be clay soil. Clay soil holds water well and usually contains plant nutrients, but it has many other problems. It does not drain well and during wet weather it tends to remain wet for a longer period and the field may easily become flooded. When it dries out, it forms a hard surface making it difficult for young plants to grow through.

The ideal soil texture is a mixture of three soil types, with some organic matter i.e. a sandy loam soil with a clay content of 15 to 20%.

4.1.2 Soil structure and soil pH

Structure refers to the arrangement of the different sized soil particles. The ideal soil has a fairly loose, brittle and crumbly structure. A compact soil structure has a negative effect on water infiltration, root penetration and is usually associated with a very high clay content in the subsoil. To improve the structure, add plenty of organic matter such as leaf mould, mature manure and compost.

Soil pH is a measure of how acidic or alkaline the soil is. Food crops usually grow well in a soil with a pH of 5.5 to 6.5. The pH can be determined in a soil testing laboratory or by use of a soil testing kit. Local farmers and extension officers should be able to tell the general trend i.e. whether the soil tends to be neutral, acidic or alkaline. Where the pH is low, lime needs to be applied into the soil at least four weeks before planting.

4.1.3 Soil nutrients

Growing crops and water drainage reduce the amount of soil nutrients available for plant use. This results in decrease in crop yield. Plants experiencing nutrient deficiencies do not grow properly. Observable nutrient deficiency symptoms include yellowing of leaves and stunting in plants. Plants need larger amounts of macro-nutrients such as nitrogen (N), phosphorous (P) and potassium (K).

The purpose of soil testing is to determine the amount of soil nutrients available in the soil for plant growth and to recommend the correct type and amount of fertilizer that must be added for successful production. It may not be possible to take a soil sample every year, but at least get the soil analyzed every five years. General fertilizer recommendations for the different crops are provided in Part 5: Fact sheets for vegetables and herbs.

4.1.4 Soil sampling for laboratory testing

It is important to take soil samples in the correct way, to ensure that the soil analysis is accurate.

How to take a soil sample:

- The samples must be representative of the area to be planted.
- The garden must be divided according to the colour of the soil, slope and soil type.
- The spots must be scattered over the whole area. We usually walk in a zig zag fashion to identify spots to take sub-samples from.
- Dig a hole 30cm deep. From any side of the hole cut a 3-5 cm slice of soil from the top to the bottom a top-soil sample. For a sub-soil sample dig the hole deeper, 30-60cm and repeat the procedure to cut a slice of soil.
- Keep top-soil (0-30 cm) and sub-soil (30 – 60 cm) samples separate.
- Mix each sample thoroughly (keep top and sub samples separate).
- Spread out the soil and take a sample (± 1 kg) of both layers.
- Place each in clean sample bags.
- Identify the sample well (add name, address, name of school, land number, date, top or sub-soil).
- Indicate the crop(s) that you intend to plant
- Send to the laboratory together with analysis required.

For analysis, soil may be sent to ARC-Institute for Soil, Climate and Water, Private Bag X79, Pretoria, 0001, Tel: (012) 310 2500.

4.1.5 Organic matter in the soil

Organic matter is decomposed (rotten) plant and animal material in the soil. Decomposition of organic matter is brought about by different micro-organisms, insects, earthworms and other animals found naturally in the soil. Most soils contain varying percentages of organic matter called *humus*. Applying compost or kraal manure at least 2 months before planting and repeating the practice every season will improve the soil. (See section 4.2.1).

Benefits of organic matter

- To improve soil structure;
- To improve water-holding capacity of the soil;
- To improve soil fertility (makes nutrients available);
- To improve soil texture;
- To improve soil aeration
- To reduce soil crusting which often retards growth.

4.2 Fertilizers

Main Categories
(a) Organic fertilizers

(b) Inorganic fertilizers (chemical fertilizers)

4.2.1 Organic fertilizers

These include compost, animal manure, green manure and earth worm humus. Most organic fertilizers break down slowly in the soil and large amounts have to be applied to have an impact. Compost and manures are natural animal waste products and plant residues which are decomposed over time to release plant nutrients. They also improve soil properties such as water holding capacity and aeration.

(a) Compost

Compost mostly provides nitrogen to the plants. Compost is made by decomposing a variety of materials of plant and animal origin e.g. plant debris, animal dung and chicken manure. Organisms such as bacteria, fungi, earthworms, snails, insects and birds help to decompose the material and turn it to humus.

Use the following in a compost heap:

Activators	Other materials you can add		Very slow to rot
Comfrey leaves **Young weeds (without seeds)** **Grass cuttings** **Chicken manure** **Pigeon manure**	Wood ash Cardboard Paper towels & bags Cardboard tubes Manures and straw Hedge clippings Perennial weeds	Egg boxes Fruit and vegetable remains Tea bags Coffee grounds Old flowers Bedding plants Rabbit bedding	Autumn leaves Tough hedge clippings Woody prunings Sawdust Wood shavings
Do NOT add the following to a compost heap: Meat, fish, diseased plants, peels of lemons, cooked food, very soapy water, coal and ash, disposable nappies, manure from dogs, cats and pigs as they may carry disease organisms and parasites that can be transmitted to humans.			

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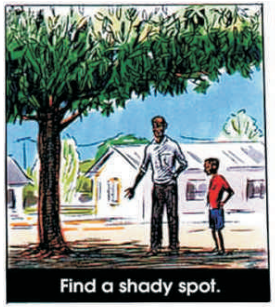
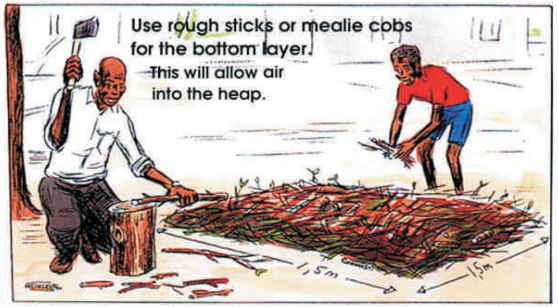
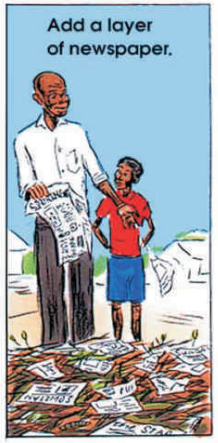
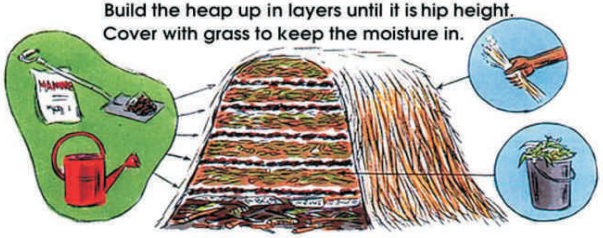
BENZA AND BETTY® INFO CARTOONS

NATURE'S FERTILISER









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(b) Green manure

Green manure, also referred to as cover crops, is grown to benefit the soil rather than for consumption. To make green manure, plant crops such as cowpeas, pigeon peas, beans, sunn hennep, clover, lupine, oats, babala, grazing rye and buckwheat, & give it time (4 to 6 weeks) to grow. Plough it in the soil and give the green material time (4 – 6 weeks) to break down before planting the vegetable Green manures such as sunn hennep can be planted on areas that lay fallow before the season (see crop rotation).It is best not to allow green manures to go to seed as they all have the potential to become weeds. Green manure replaces and holds nutrients, improves the soil structure and increases its organic material content. Legumes such as beans and cowpeas can also be utilized in the feeding program (NDA, 1997).

(c) Animal manure

Animal manure is organic material consisting of the residues of plants that were undigested by the animal and metabolic waste products such as urea and uric acid. The bedding of animals contains many valuable nutrients, especially nitrogen, as it absorbs urine (NDA, 1997).

The quantity and kind of nutrients present in manure depend on:

- The type of animal the manure comes from and the food it ate;
- Whether straw is used as bedding;
- How the manure is handled before it is used.

Regarding quality, poultry manure is normally the best, followed by sheep, horse and cattle.

Tips for using manure:

- Use poultry manure carefully because it contains large quantities of Nitrogen. Apply it lightly and work it well into the soil before planting
- Do not use poultry manure when planting root crops.
- Manure should be covered. Rain can wash out many nutrients.
- Manure should be worked into the soil as soon as possible
- Cabbage reacts well to manure and compost that has been worked into the soil before planting.

(d) Earthworm humus

Vermiculture or earthworm composting produces high quality compost and fertilizing liquid with earth worms and household waste.

Make your own worm compost

- Drill drainage holes approximately 25 cm apart and 5 cm from the base of plastic containers or rubber/wood/galvanized tubs. The holes allow surplus water, which is liquid fertilizer, to drain off. Drill other air/ventilation holes 5 cm from the top of the bin and some on the lid.
- Fill bin with 8 – 10 cm layer of coarse sand or gravel and on top of it place wood or polythene with holes drilled for drainage.
- Add a 7 - 8 cm layer of bedding with semi-composted organic material such as moist shredded newspaper and cardboard, fall leaves, straw and other dead plants, compost manure. Vary the bedding in the bin as much as possible, to provide more nutrients for the worms and to create a richer compost. Add a couple of handfuls of sandy loam soil to provide necessary grit for the worm to digest food.
- Place the worms, preferably red wigglers (branding) and eggs in the bedding.
- Bury chopped food scraps such as bread, grains, cereals, fruit and vegetable peels, crushed egg shells, tea/coffee bags, at the different side of the container each week. Do not feed the worms citrus peels and other acidic foods, meats, dairy products and oily foods.
- Replace the lid and leave undisturbed for at least 2 weeks for the worms to settle.
- Harvest the compost by dumping the container contents onto a large plastic sheet under a bright light or sun. Make several small heaps on the sheet, the worms will burrow to the bottom of each heap to escape the light. Scrape off the top of the compost and store or use it.
- Return the worms and cocoons to the bin with new bedding.

Troubleshooting

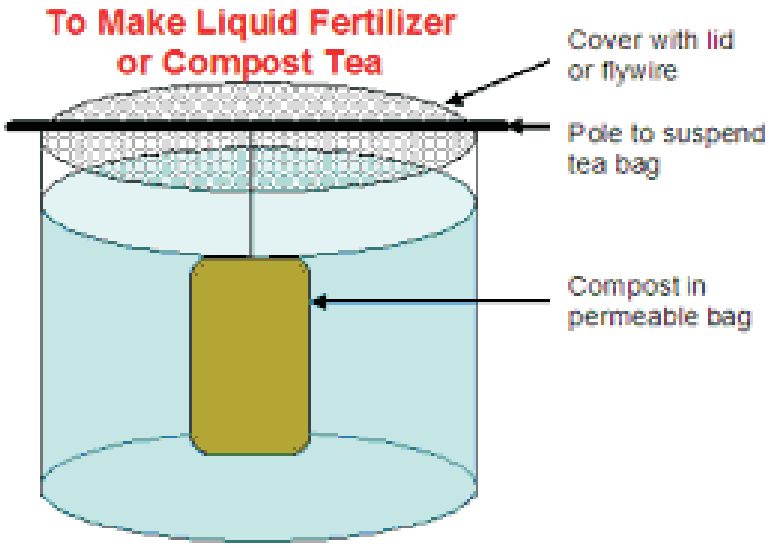
Problem	Cause	Solution
Worms die or try to escape	Too wet, Too dry, Bedding is used up	Add more bedding Moisten bedding Harvest the bin
Unpleasant smell	Too wet Not enough air Too much food	Add more bedding Drill more air holes/ Stir up the entire contents to allow air Do not feed for 1-2 weeks
fruit flies	Exposed food	Bury food in the bedding

Source: ***http://whatcom.wsu.edu/ag/compost/easywormbin.htm)***

More information can be found in the internet sources listed in the References

(e) Liquid manure

- Fill a large bucket or bin that has a fitting lid with water.
- Put any animal manure (cow, horse, rabbit, sheep, chicken) or chopped green manure (green hedges or trees, lawn clippings, seaweed, weeds or comfrey) into a compost "tea bag" (onion bag/hessian sack/nylon sack/square of shade cloth). Tie the end of the manure bag with a piece of string. Connect the tied portion of the bag to the middle of a sturdy stick
- Immerse it in the water and cover with a lid. Stir the liquid plant fertilizer every few days. Allow the liquid mixture to ferment for about 6 - 8 weeks.
- Remove the manure bag from the liquid and dispose of the entire contents. Pour the manure tea/liquid into another containers and store until it is needed for plants.
- To use compost tea:
  Dilute the tea at the rate of about 1 part concentrate to 4 parts water, and apply directly to the plants. It will be more valuable if applied during the peak leaf growth, flowering and fruiting stages of the plants. The residue in the container can be used for the worm farm or compost.



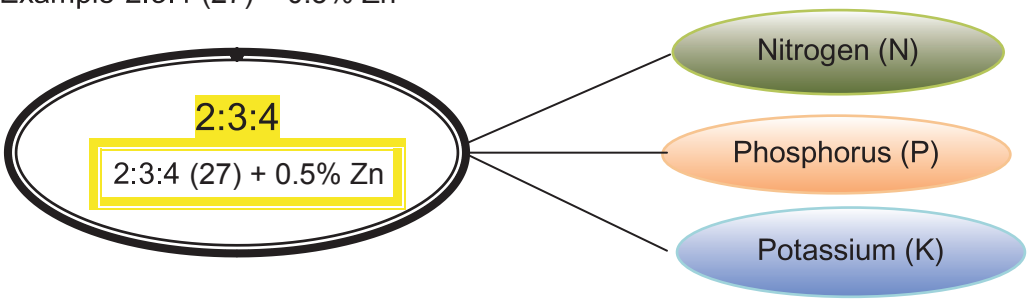
Source: http://www.small-farm-permaculture-and-sustainable-living.com/compost_tea_organic_farming_and.html

4.2.2 Chemical fertilizers (inorganic fertilizers)

Chemical fertilizers are sold as mixtures or single element fertilizers. Most of these do not only contain nutrients but also contain fillers and conditioners. The amount of nutrients is always displayed on the label as a percentage.

Reading the label:

Example 2:3:4 (27) + 0.5% Zn



2:3:4 is the ratio of nitrogen, phosphorus and potassium in the fertilizer mixture.

(27) is the total (mass) percentage of the nutrients in the mixture. This means in a 50kg bag 13.5kg (27% of 50kg) is nitrogen, phosphorus and potassium.

To calculate amount of nitrogen, phosphorus and potassium		**To determine the percentages of each nutrient in the mixture**
N	2/9 x 13.5kg = 3.0 kg	N 2/9 x 27 = 6% and 6% of 50 kg = 3 kg
P	3/9 x 13.5kg = 4.5 kg	P 3/9 x 27 = 9%
K	4/9 x 13.5kg = 6.0 kg	K 4/9 x 27 = 12%
		The mixture also contains 0.5% zinc (Zn).

Safety Tips

- Always read the labels and directions before use.
- Store in a dry, secured place.
- Do not store with food.
- Wash hands after use.
- Do not bring into contact with mouth and eyes.
- Children must always use fertilizers under supervision
- Do not harvest vegetable and fruit immediately after applying the chemicals. Observe the recommended waiting period.

Liquid fertilizers

These are fertilizers that are already dissolved in water and are ready to use e.g. Multifeed & Chemicult. Some can be applied directly to the plant leaves while others are applied through the irrigation system. It is the fastest way of applying plant food.

4.2.3 Guidelines for fertilizer application

Ideally, fertilizer applications should be done according to the recommendations from soil analysis. When the amount of fertilizer to be applied is known, it is necessary to follow particular guidelines when applying it.

Phosphorous (P) and Potassium (K) are normally applied to the soil before planting.
Do not apply the KAN/LAN fertilizer directly onto the plants because it will burn the leaves.
Nitrogen (N) application depends on the crop requirement and soil texture. Heavy clay soils require N to be applied at planting while sandy soils require additional side dressings about 3-4 weeks after planting.
Side dressings should be applied at least 4cm from the stem to avoid damage to the crop.
Work the fertilizer into the top soil and water the soil thoroughly thereafter

Other methods used for fertilizer application include *fertigation* which is the application of fertilizer through the irrigation system and *foliar* which is application of fertilizer on the leaves. Foliar application is mainly used for the application of micro-elements such as manganese (Mn), iron (Fe) and copper (Cu), which are required by plants in small amounts.

4.3. Soil preparation

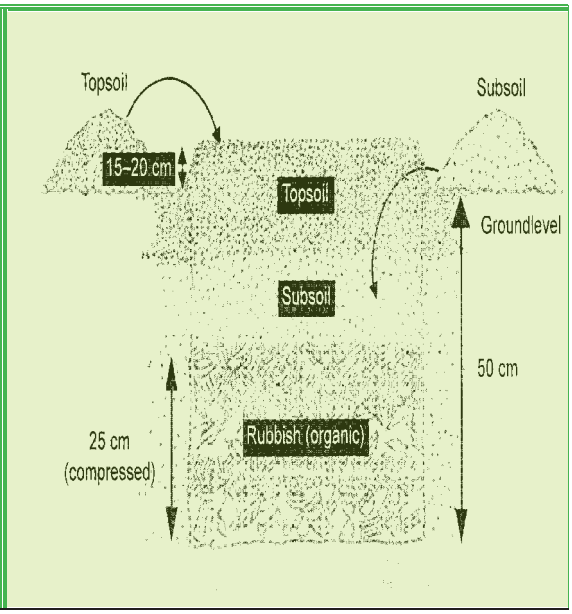
Proper soil preparation is essential for:

- Good conditions for germination of seeds;
- Better root development;
- Better water absorption and drainage (less run-off);
- Better absorption and utilization of nutrients;
- Improved management of weeds, pests and diseases.
- Removal of all perennial weeds.

Soil preparation is done by hand in small garden. Mechanical preparation is used in large gardens. The first step is to loosen the soil deeply and make sure that all weeds are taken out. Then apply fertilizer if necessary, break up clods, even out and moisten the soil. It is important that plots are moist and free from clods and weeds.

4.3.1 Trench gardens

- Mark out the area of each bed, usually 1 m x 2 m, and leave space between beds to enable movement
- Dig the soil over making trench at least 50 cm (knee deep). Keep the first soil that is dug out(the top soil), apart from the subsoil.
- When filling the trench, place solid rubbish such as tins, eggshells, bones, wood and paper at the bottom to assist in drainage. Then proceed with alternating layers of soil (subsoil) and organic material such as grass, weeds, small branches and leaves. Lastly add the topsoil that was kept apart.
- The organic material layers will act like a sponge holding moisture to a good depth. Manure or compost can be dug into the topsoil. Leave the beds like this for a week. Water well before planting and allow the soil to drain until it can be worked without becoming muddy.

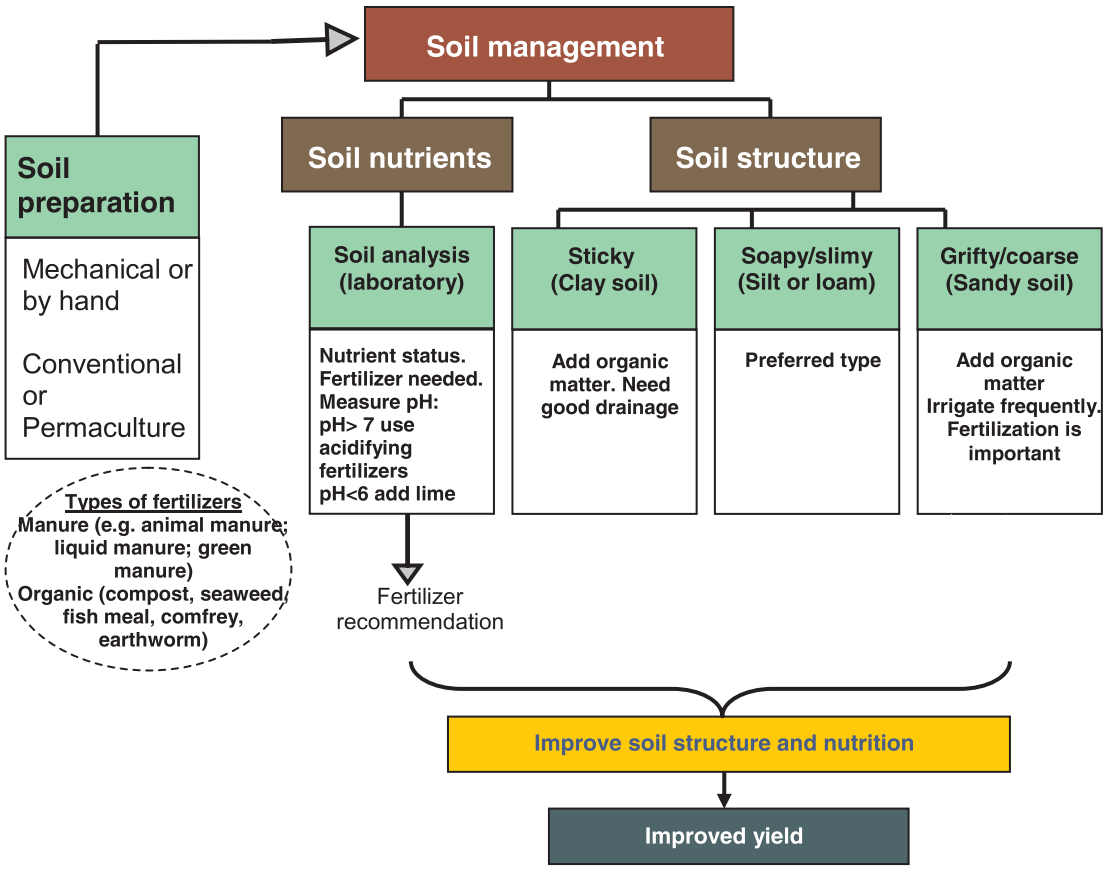


Making a trench garden (Source: Department of Agriculture, 2002)

4.3.2 Conservation Agriculture

Conservation Agriculture (CA) entails improved water, soil and nutrient management options such as improved soil health and fertility; better water infiltration and retention; reduction of soil erosion; and improved integrity of catchment areas; promotes biodiversity through crop rotations and use of cover crops (FAO, 2009). CA enhances the biological activity and diversity in the cropping environment, and is an important element for natural pest, disease and weed management under Integrated Pest Management (IPM) environment (see section 4.6).

A schematic summary of soil management and soil preparation (sections 4.1 to 4.3) is provided below:



4.4 Garden layout

If a large land is available, it is possible to plan a big area with definite plots to make it easier to manage and to work out a crop rotation system. In cases where a small land is available space efficient techniques can be used.

4.4.1 Space efficient techniques

Container Gardens

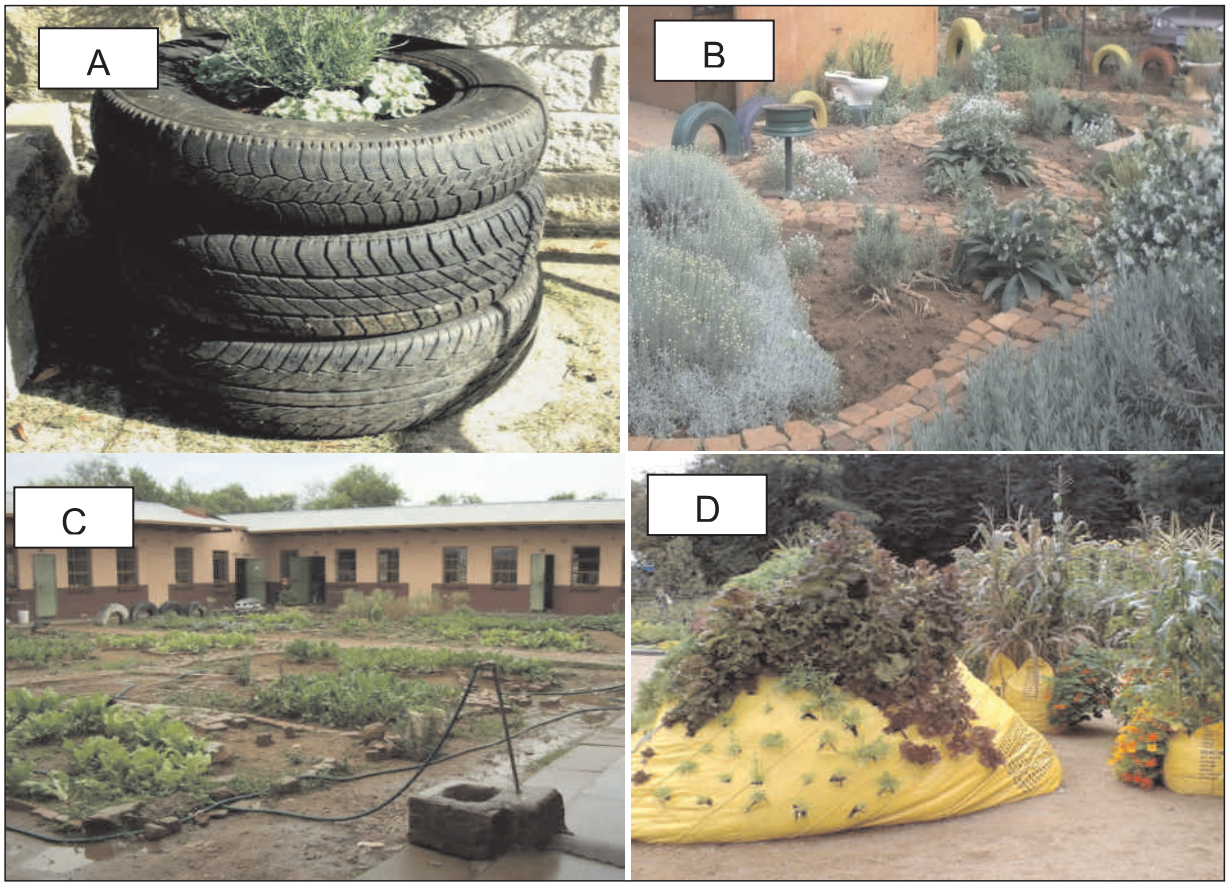
A small garden can be made in any container which can hold soil together for a plant to grow and bear leaves/fruit. Space saving gardens can be made in car tyres, bags and other containers. Tower gardens (stacked tyres/standing bag) maximize horizontal space and are ideal for growing potatoes and sweet potatoes. Don't forget to make holes in the base of the container and put stone/gravel for drainange. This type of garden can be moved easily if necessary.

4.4.2 Elements of the garden layout

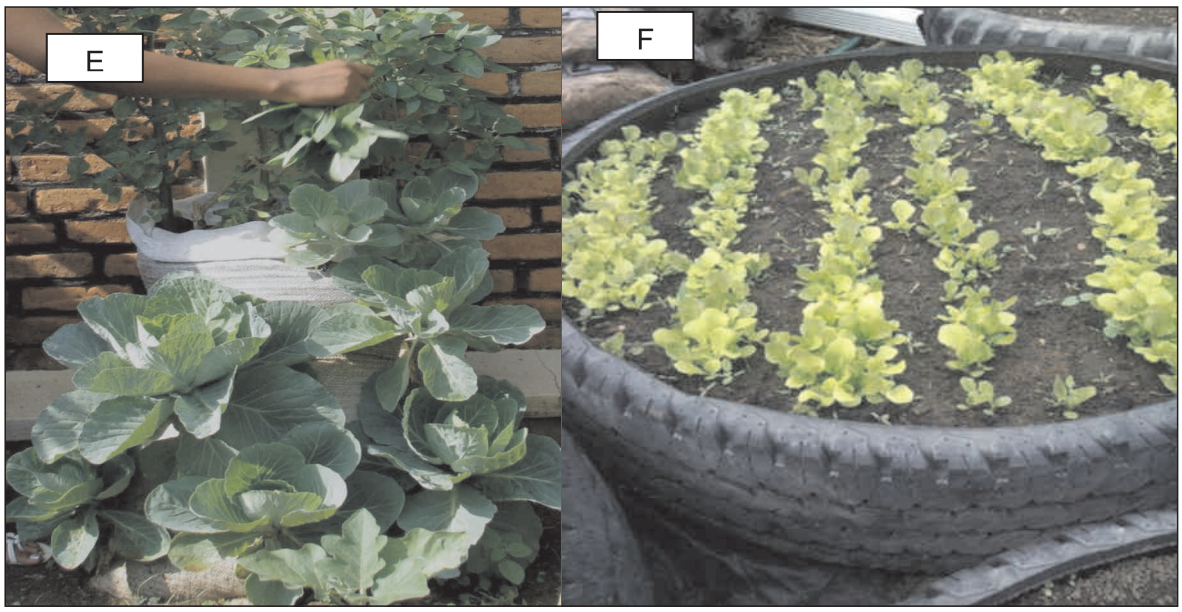
If possible try to establish the garden close to the classrooms. It helps for supervision, live lessons up and keep predators away. The most important elements for a garden are plots, ridges, seedbeds, paths, watering system, compost/manure heaps and a shed .

Make sure to follow a systematic procedure when you plan the layout of your garden. For example:

- Make a sketch plan of the garden to scale, and divide it into comfortable units. Give each unit a number for future reference.
- Give priority to vegetables needed for the school feeding programme.
- Separate perennial and annual vegetables, vegetables with long and short growing periods.
- Separate summer and winter vegetables.
- Leave space for varying planting dates for vegetables such as carrots, beet, spinach, beans, etc. to ensure continuity through the season.
- Place crops that need to be trained or trellised at the edges of the garden plot.
- Make provision for pathways.



Ideas for garden layout in a school: (A) Tyres can be used for planting of various crops; (B) The herb garden can form part of the flower garden of the school. Any useful containers may be used; (C) Design of vegetable plots in a school court yard (D) Bag garden



(E) Bag gardens (F) Tyre garden used to produce seedlings.

(a) Types of beds

If the soil holds a lot of water it is better to use raised beds or ridges. To prepare a raised bed dig over the soil and add compost, then remove the topsoil from the paths and heap it up on the beds 10-15 cm high. Beds (see preparation in Section 4.5.2) are used most for crops that are sown directly e.g. carrot, and also to ensure drainage e.g. onion, beetroot, spinach transplants. Make sure the beds are made across the slope to catch rain water and prevent erosion.

(b) Slope

Sloping ground needs more preparation and attention than flat areas because it can cause soil erosion. Mulch or terraces are the best solution for such problem areas. A terrace with 1.2 to 1.5 m wide beds across the slope with narrow paths in between should be sufficient. Bed levels must always be maintained, particularly during the rainy season.

A slight slope can be beneficial to collect run-off water where crops are planted (See 4.9.2 water harvesting).

4.4.3 Crop rotation

Crop rotation is one of the basic principles of vegetable production and should always be practiced. Crop rotation is a system of crop production in which the various crops are grown in a certain sequence in such a way that no crop is planted on the same piece of land more than once in four planting cycles. The greatest benefits of crop rotation are to improve and conserve the soil as well as the reduction of disease levels, insect population and perennial weed infestation in the soil. Many pathogens can persist in the soil after the crop has been removed e.g. black-rot of cabbage, and if the following crop is still cabbage (or a relative), there will be a

high rate of infestation. Below is an example of a rotational cropping system with 3 plots over 5 **growing seasons** (cycles) The growing season can be any period between successive plantings. For some crops (e.g. field crops) it is a year and for others it can beufo r months. In one year one can, therefore, grow three crops in succession on the same piece of land.

Cycle	Plot 1	Plot 2	Plot 3
1	Leafy crops	Legumes	Brassicas
2	Solanaceae	Leafy crops	Legumes
3	Root crops	Solanaceae	Leafy crops
4	Brassicas	Root crops	Solanaceae
5	Legumes	Brassicas	Root crops

The crops included in the plots shown above are as follows:

Legumes	-	Beans, Peas, Cowpeas, Pigeon peas, Bambara
Brassicas	-	Cabbage, Chinese cabbage, Kale, Radish, Cauliflower
Root crops	-	Carrots, Onions, Beet, Sweet potato, Amadumbi,
Solanaceae	-	Tomato, Potato, Peppers
Leafy crops	-	Swiss Chard, Amaranthus, Cleome

Cucurbits (Pumpkins, Squash, Melons, Cucumbers) and green mealies can be included in the rotation at any point.

4.4.4 Staggered planting

Staggered planting is when smaller but regular plantings are made at intervals (e.g. every four weeks) during the planting season so as to ensure a continuous supply of the crop. Maturity can be predicted by use of a guide showing days from planting to harvest for each crop. Continuity can also be achieved from single plantings with certain crops e.g. butternut. When the rows are thinned, the removed plants can be used to plant further rows which will mature slightly later.

4.4.5 Examples of planting plans

Examples of planting plans for different climatic zones are provided below:

Planting and harvesting chart for priority vegetables in mild winter areas (light frost)

CROP	Activity	August	September	October	November	December	January	February	March	April	May	June	July
OFSP*	Plant			√	√	√	√						
	Harvest							√	√	√	√	√	√
Beans	Sow		√	√	√	√	√						
	Harvest					√	√	√	√	√			
Beetroot	Sow	√	√	√				√	√				
	Harvest				√	√	√				√	√	√
Cabbage	Sow	√	√					√	√				
	Transplant		√	√	√				√	√			
	Harvest				√	√	√				√	√	√
Carrot	Sow	√	√	√			√	√	√	√			
	Harvest	√		√	√	√	√	√			√	√	√
Spinach	Sow	√	√	√				√	√	√			
	Transplant		√	√	√				√	√	√		
	Harvest	√	√	√	√	√	√	√	√	√	√	√	√
Pumpkin/ Butternut	Sow	√	√	√	√								
	Harvest						√	√	√	√	√		

*OFSP = Orange-fleshed sweet potato

Planting and harvesting chart for priority vegetables in warm winter areas (without frost)

CROP	Activity	August	September	October	November	December	January	February	March	April	May	June	July
OFSP*	Plant	√	√	√	√			√	√				
	Harvest	√	√				√	√	√	√	√	√	√
Beans	Sow		√	√	√	√	√						
	Harvest					√	√	√	√	√			
Beetroot	Sow									√	√	√	
	Harvest	√	√	√									
Cabbage	Sow	√	√						√	√			
	Transplant		√	√						√	√		
	Harvest				√	√						√	√
Carrot	Sow	√	√	√					√	√	√	√	
	Harvest	√	√	√	√	√					√	√	√
Spinach	Sow	√	√	√				√	√	√	√	√	
	Transplant		√	√	√				√	√	√	√	√
	Harvest	√	√	√	√	√				√	√	√	√
Butternut/ Pumpkin	Sow	√	√	√									
	Harvest				√	√	√	√ use stored produce					

*OFSP = Orange-fleshed sweetpotato

Planting and harvesting chart for priority vegetables in cold winter areas (heavy frost).

CROP	Activity	August	September	October	November	December	January	February	March	April	May	June	July
OFSP*	Plant				√ 1 Nov & 15 Nov	√ 1 Dec & 15 Dec							
	Harvest									Harvest 1 Nov planting	Harvest 15 Nov planting	Harvest 1 Dec planting	Harvest 15 Dec planting
Beans	Sow		√ from 15 Sep	√	√	√	√						
	Harvest					√	√	√	√	√			
Beetroot	Sow			√	√	√	√	√	√				
	Harvest	√					√	√	√			√	√
Cabbage	Sow	√	√					√	√				
	Transplant		√	√	√				√	√			
	Harvest				√	√	√				√	√	√
Carrot	Sow	√	√	√	√	√	√	√	√	√	√		
	Harvest	√	√	√	√	√	√	√	√	√	√	√	√
Spinach	Sow	√	√	√	√	√	√	√	√	√			
	Transplant	√	√	√	√	√	√	√	√	√			
	Harvest	√		√	√	√	√	√	√	√	√	√	√
Butternut/ Pumpkin	Sow		√	√	√	√							
	Harvest					√	√	√	√	√ use stored produce	√ use stored produce		

*OFSP = Orange-fleshed sweetpotato

Planting and harvesting chart for priority vegetables in winter rainfall areas.

CROP	Activity	August	September	October	November	December	January	February	March	April	May	June	July
OFSP*	Plant				√ 15 Nov	1Dec & 15 Dec							
	Harvest								√	√			
Beans	Plant		√	√	√	√	√	√					
	Harvest					√	√	√	√	√	√		
Beetroot	Plant			√	√	√	√	√	√				
	Harvest	√					√	√	√			√	√
Cabbage	Sow	√	√					√	√				
	Transplant		√	√	√				√	√			
	Harvest				√	√	√				√	√	√
Carrot	Sow	√	√	√	√		√	√	√				
	Harvest			√	√	√	√		√	√	√		
Spinach	Sow	√	√						√	√			
	Transplant		√	√						√	√		
	Harvest				√	√					√	√	
Butternut	Plant	√ (sow in protected site)	√ (transplant the seedlings)	√	√	√							
	Harvest					√	√	√	√	√ use stored produce			

*OFSP = Orange-fleshed sweetpotato

4.5 Seeds and Seedlings

4.5.1 Seeds

Always use certified seed for planting. Always read the back park of a seed packet. It has simplified information on sowing season, planting position (in the sun or shade), spacing, days to harvest and the expiry date. If seeds are not used immediately, the packet/containers must be sealed and stored in cool dry place. Seeds must be without mould, scratches or holes. A small germination test can be done to check the germination efficiency of the seed by placing the seed in moist cotton wool and checking germination after five to six days.

4.5.2 Seedling production

Sow the seeds at least 4 weeks before the planned transplanting date.

(a) Sowing in seedling trays

Equipment: Shade net structure; irrigation equipment; good growing medium (sterile and free from pathogens); sterilized and clean seedling trays; watering can with very fine nozzles; clean basin/bucket for moistening the medium before filling the trays; mash/w table for keeping the seedling trays. or place trays on pots. (seedlings trays must not stand directly on soil).

Sowing: Choose trays with cavities large enough to prevent major restriction of the seedling root system after 3 - 4 weeks. The medium should be well aerated, with a good water holding capacity. Old seedling trays must be sterilized with JIK to destroy fungi and bacteria before re-using them. The medium must be moist when it is placed into the tray. Each hole must be filled properly and then hollowed to a depth of 3 times the diameter of the specific seed. Place one seed per hole and cover it with a thin layer of soil or a growth medium. Irrigate with a very fine nozzle to make sure that the seeds are not washed out. Never let the soil dry out or be too wet.

(b) Sowing in seedbeds

Requirements : a sunny spot that is protected from wind and cold; watering can with very fine nozzles, fork, shovel, hand hoe, rake for preparing the seedbed and fertilizers.

Sowing : Seedbeds should be made in a sunny spot that is protected from wind and cold. Loosen the soil and break up all clods. Make fine seedbeds of 1 m x 2 m size. Apply 100 g of a fertilizer mixture or four hands full of compost per square meter. Use a spacing of 6cm x 6 cm for spinach up to 12 cm x 12 cm for butternut. This spacing is needed to scoop out the seedlings with a plug of roots and soil. During the warmer months, mulch the rows with dry grass to keep the soil cool and moist. In cold areas, remove mulch during the day and cover at night to keep the cold out. The mulch should be removed after the seedlings have emerged because if it is kept for too long, the seedlings will become leggy weak. Orange/onion bags can be sewn together and placed over the seedbed to protect them against birds.

(c) Maintenance

Water frequently. The seedlings must not stress while they develop and must receive enough fertilizer to protect weak seedlings which are prone to pests and diseases. Over irrigation and poor drainage causes diseases such as damping off. A green layer of algae on the soil surface normally indicates poor drainage. The seedlings will emerge 7 to 14 days after planting, depending on the variety, weather, soil type and the season. They must be protected against sunlight, hail and birds.

(d) Hardening-off

A week before transplanting, expose the seedlings to the environment where they will grow. This will include irrigating less frequently and exposing them to the sun.

4.5.3 Transplanting seedlings

Make sure that the seedlings are not damaged when they are removed from the tray by pushing them gently from below. Scoop out the seedlings from the seedbed with a hand shovel, ensuring that they have a plug of roots and soil. Transplant during a cool time of the day. Planting holes must be prepared according to the necessary spacing before the seedlings are removed from seedbed. Water the plants after transplanting.



Time to transplanting of some crops:

- Tomato: 5 – 6 weeks
- Cucumbers: 4 – 5 weeks
- Swiss chard: 3 – 4 weeks
- Cabbage: 5 – 6 weeks
- Onions: 7 – 8 weeks

4.6 Management of pests and diseases

Garden pests, diseases and weeds are major problems in vegetable production. Pests and diseases attack seeds, leaves, flowers, fruits, stems and roots of cultivated vegetables and thereby cause losses (during the growing season and storage) and reduce the quality of the produce.

Information on vegetable pests

What is a pest?

- it is any organism that competes with humans through lowering the quantity or quality of a crops that are being produced.
- almost all known pests are insects, however, most insects are NOT pests;
- insects only become pests when they cause economic losses in crops;
- some pests are wide feeders, attacking a wide range of plants while others only attack specific crops.

How does a pest establish in a crop?

- infection from "off season" material (crop remains);
- propagation material;
- fly in.

What causes an outbreak of a pest?

- optimum weather conditions;
- lack of natural enemies;
- resistance against insecticides;
- use of wrong chemicals

Information on plant diseases

What are plant diseases?

- mainly microscopic organisms which live at the expense of the plant;
- include bacteria, fungi and viruses.

How do they spread

- wind (spread over long distances);
- rain splash and overhead irrigation (spread over short distances);
- runoff and flood irrigation;
- insects;
- diseased seeds, seedlings and vegetative planting material (spread over very long distances, even between countries);
- boots and shoes worn by people;
- equipment used in the garden (e.g. garden forks, hoes, pruning scissors); and
- plants left in garden from the previous season.

Pest and diseases and their control on specific vegetable crops are discussed in Part 5.

Of specific importance is soil borne pests and diseases of vegetable crops in South Africa. At present, the control of many of these pests and diseases depends primarily on application of chemicals (e.g. pesticides and fungicides). Chemical control is expensive, can be a serious health hazard to both producer and consumer and can contaminate the environment. Not all pests and pathogens are successfully killed and those not killed can develop into more aggressive races resistant to these chemicals. Chemicals also kill beneficial insects.
It is recommended that other strategies such as Integrated Pest Management (IPM) be used.

4.6.1 Intergrated Pest Management (IPM)

Intergrated Pest Management (IPM) aims to protect crops with minimal usage of chemicals. It entails the use of various long term strategies, aiming at prevention of pests and diseases, by keeping existing pest and pathogen populations low and promote vigorous, but balanced, plant growth. The attention to vigorous plant growth is a further development of (IPM) called Intergrated Production and Pest Management (IPPM). Summary of methods employed in IPPM:

(a) Prevention (cultural, mechanical and physical control)

- Selection of site, species and varieties: Where possible, select crops and cultivars which are tolerant to existing site conditions e.g. disease tolerant or drought resistant cultivars.
- Selection of optimal planting and harvesting time as well as optimal plant spacing.
- Diversity: Follow a proper crop rotation system (Section 4.3.3). Cover crops and intercropping are useful in breaking disease cycles of pathogens (and pests).
- Soil management: Maintain a high level of soil nutrients for optimal plant growth. Weaker plants are more prone to attack by diseases and pests, improving soil quality will ensure healthier more resistant plants. The best means of improving soil quality are: crop rotation, incorporating crop residues, addition of animal manures and the use of green manure crops, including nitrogen-fixing legumes.
- Sanitation: Using disease-free seed and planting material (do not save seeds from fields that were infected), cleaning of implements, stakes and equipment with JIK solution, removing infected plants.
- Remove weeds. Weeds can host harmful viruses and insects.

(b) Observation

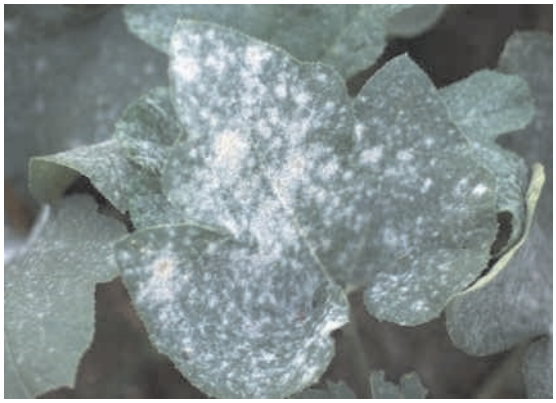
- Scouting: Systematically inspect a representative sample of each crop on a regular basis (at least once a week) to quantify pest populations or crop damage. Record the findings. Make a decision if intervention is required.

(c) Intervention

- **Biological control:** Beneficial insects (e.g. wasps, ladybirds, bees and spiders) exist everywhere in nature and should be preserved whenever possible. Bees help with pollination and predatory ladybirds feed on aphids. Biological control entails the use of beneficial organisms introduced to control pathogens e.g. microbial pesticides.
- **Mechanical control:** Remove harmful insects by hand. Usage of insect traps or erecting insect barriers.
- **Chemical control:** Apply chemicals for pests and diseases only when considerable damage occurs (e.g. when the economic threshold level is exceeded). For environmental sustainability, use chemical *(pesticides)* that are environmentally friendly. The so-called softer chemicals are natural substances derived from plants (*e.g.* pyrethrum and garlic sprays). Alternative control methods (See 4.6.3) or companion planting (See 4.6.4) are promoted for minor pests and diseases. However, preventative spraying of chemicals are required to control certain major pests and

diseases to avoid excessive damage. For example, a major pest like leaf minor on potato, needs to be controlled as soon as detected. There are two types of chemicals namely systemic and contact sprays. Contact sprays kills insects or fungi when the spray comes into contact with the organism. Systemic substances are absorbed by the plant, translocated to every organ and provide protection against attack by the specific pest or disease.

Leaf minor damage on a potato leaf.



Powdery mildew (fungus) on pumpkin leaves.

When designing an IPPM strategy, take factors such as the topography, soil characteristics, climate, pests, local availability of inputs and the specific crop produced, into account. Furthermore, the timeliness of application of practices are important, as well as proper record-keeping regarding weather conditions, pest populations, crop conditions and control procedures all season. Good records help determine which pest control strategies are working and where improvements should be made in future.

4.6.2 Safety precautions when using chemical sprays

- Make sure that the correct chemical is used for the specific problem that needs to be controlled. This is listed on the container's label. It is important that the problem is diagnosed correctly.
- Read the instructions on the container's label and adhere strictly to them. If in doubt regarding the procedures do not use the chemical.
- Do not use stronger concentrations or larger dosages than recommended.
- Store chemicals locked away in clearly labelled and closed original containers.
- Destroy empty containers appropriately.
- Never store in cold drink or other bottles previously used for human consumption
- Never spray or apply during windy conditions.
- Use appropriate masks, hand cloves and protective clothing.
- Do not harvest after spraying. Follow the waiting period instructions.

4.6.3 Alternative control methods

- **Bio-fumigation**: Using *Brassica* (cabbage family) crops as soil amendments to suppress of soil – borne pests and diseases such as *Fusarium* wilt, *Verticillium* bacterial wilt and nematodes. Plant *Brassica* crops (cabbage, cauliflower, kale, cleome, canola, mustard) in rotation with other vegetable crops and let it grow until 50% flowering. Incorporate the fresh plants into the soil. Alternatively dry the cut off plant in the sun for 10-14 days (depending on the climatic conditions). Incorporate the dried plant residue approximately 30 cm deep into the soil as green manure. It is important to allow at least 10 days after incorporation before any crop is planted as it may harm the follow-up crop.

- The use of plastic or organic **mulch** (See Section 4.8.6) provides a barrier between soil and plant and reduces the amount of incoming disease organisms splashed onto plant parts during rain/irrigation.

- **Soil solarization** can be used to control root-knot nematodes in the soil as well as soil borne diseases and pests. In hot months, wet soil is covered with plastic for 4-6 weeks. Bury the edges of the plastic with 15 cm of soil. Plant crops immediately after removing the plastic.

- **Household sprays:**

Light Liquid soap spray

To control aphids
Mix a tablespoon of cooking oil and a few drops of liquid soap in 1 liter of water.

Agricultural lime

To control for ants, termites, snails, slugs and acid-loving weeds in the garden, sprinkle 125 g (1/2 cup) of agricultural lime per m^2
(Not recommended for soil with high pH).

To control or repel aphids, cabbage fly, mites, thrips, tomato flies, white fly, cutworms, red spider mite, all types of beetles, moths, etc.

Method:

- Roughly cut a full pod ,including the skins, of garlic and 4 onions
- Place in a container and add a tablespoon of crushed dried or fresh chilly or chilly seeds, or one teaspoon of chilly powder
- Pour over 3 liters of boiling water, close the container and allow it to stand for one day.
- Strain, in the fluid add 2 tablespoons of cooking oil and add 2 teaspoons of liquid soap and Mix well (*Note that too much oil will be harmful to the plants*)
- Mix one cup of this mixture with 5 cups of water
- Spray the plants weekly
- Make up fresh every week
- Garlic sprays are also sold commercially

Companion planting is the planting of certain crops close to one another so that they can assist each other in nutrient uptake, pest control (naturally without using chemicals), pollination, and other factors necessary to increase crop productivity.

Companion planting of e.g. flowers next to a food crop, can disrupt the searching pattern of the pests looking for host plants. They detect the host plants but become disrupted with the more diverse planting style. The diverse canopy resulting when corn is companion-planted with squash or pumpkins is believed to disorient the adult squash vine borer and protect the vining crop from this damaging pest.

Some plants discharge chemicals from roots or aerial parts that suppress or repel pests and in that way protect neighbouring plants. Examples:

- Marigold, releases a nematode repellent and is thus a good companion for a number of food crops.

- Separating rows of cabbages, broccoli or other *Brassicas* with rows of onions is a popular combination because the onion's strong scent disrupts cabbage pests.
- Tomato plants grow well next to cabbages because cabbages to deter caterpillars.
- A variety of herbal plants inter-planted with the vegetables or around the vegetable patch can have beneficial effects, e.g. Basil planted together with tomatoes and lettuce may deter insects. Origanum planted together with broccoli repels cabbage flies.

(c) Positive hosting/Beneficial habitats

The benefit is derived when companion plants provide a desirable environment for beneficial insects - especially predatory and parasitic species which help to keep pest populations in check. Predators include ladybird beetles, lacewings, hover flies, mantids, robber flies, and non-insects such as spiders and predatory mites. Parasites include a wide range of wasps.

(d) Increased level interaction

Plants that grow on different levels in the same space thus providing ground cover or working as trellis for other plants. The maize stalk provides support for the beans to climb on, the beans give squash and maize nutrients in the soil and squash serves as a shade to the roots of maize and beans which grow beside it. Additional benefits include space and water saving.

Below is vegetables, herbs and trees companion planting chart to help you learn more about the most common crops that you might want to consider planting together in your garden

Plant	Good Companions	Bad Companions/ Dislikes
Amarath	Beetroot, Mealies, Onions, Potatoes, Sorgum	
Apricot	Basil, Buckwheat, Nasturtiums Peaches, Plums, Rosemary, southernwood, tansy	Barley, brinjals, oats, potatoes, tomatoes, wheat
Beans (bush)	Beets, Cabbage, Carrots, Celery, Maize, Cucumbers, Leek, Lettuce, Parsnip, Pea, Potatoes, Radish, Rosemary, Strawberry, Sunflower, Tansy, Marigold, Moringa tree	Basil, Fennel, all members of Onion family
Beans (ranking)	Carrots, spinach,mielies Cucumber, Lettuce, Marigold, Peas, Potatoes, Radish, Rosemary, Strawberry, Moringa tree	Basil, Beets, Cabbage, Fennel, Onion, Radish, Sunflower
Beets	Bush Beans, Cabbage family, Lettuce, Beans, Onion, Radish, Sage	Mustard,Ranking Beans
Cabbage Family	Bush Beans, Beets, Carrot, Celery, Cucumber, Lettuce, Mint, Nasturtium, Onions, Rosemary, Sage, Spinach, Thyme, All Strong Herbs, Marigold	Ranking Bean, Strawberry, Tomato
Carrots	Beans, Brussels sprouts, Cabbage, Chives, Lettuce, Leek, Onion, Peas, Radish, Rosemary, Sage, Tomato	Celery, Dill
Garlic	Beetroot, chard, lettuces, tomatoes, lemon and orange trees	Beans, Broccoli, Cabbage, Peas, Strawberies
Lettuce	Everything, but especially Carrots, Garlic, Onion Radish, Moringa tree	— none —
Maize	All Beans, Beets, Cabbage, Cucumber, Melons, Parsley, Peas, Early Potatoes, Pumpkin, Squash	Tomato
Moringa	Jugo beans, lettuce, spinach, tomatoes	
Onion	Beets, Cabbage family, Carrots, Celery, Cucumber, Lettuce, Parsnip, Pepper, Spinach, Squash, Strawberries, Tomato, Turnip, Savory	Asparagus, Beans, Peas, Sage
Peaches and Pears	Borage, garlic, onions, tansy	
Potato	Bush bean, Cabbage family, Carrot, maize Horseradish, Marigold, Onion, Parsnip, Peas	Cucumber, Parsnip, Pumpkin, Squash family, Sunflower, Turnip, Fennel,
Pumpkin (cucurbits)	Beans, garlic chives, mealies, radishes, onion	
Radish	Beet, Bush Beans, Pole Beans, Carrots, Cucumber, Lettuce, Melons, Nasturtium, Parsnip, Peas, Spinach, Squash family	Hyssop
Swiss Chard / Spinach	Beetroot, Cabbage, Celery, green peppers, onions, peas, strawberries, Moringa tree	Grapes, sage
Strawberry	Bush Beans, Lettuce, Nasturtium, Onion, Radish, Spinach	Cabbage, Potato
Tomatoes	Asparagus, Bean, Cabbage family, Carrots, Celery, Chive, Cucumber, Garlic, Head lettuce,	Pole beans, Corn Dill, Fennel, Potato
	Marigold, Mint, Nasturtium, Onion, Parsley, Pepper, Marigold, Moringa tree	

Kuepper & Dodson (2009) and Roberts (2007)

4.7 Weed control

A weed is any plant that is growing where it is not wanted. Weeds are a major problem in many vegetable gardens. They compete with food crops for nutrients, water, sunlight and space. Weed-infested crops grow poorly and can be overgrown by weed, leading to a total crop failure. Densely weeded areas can harbour rats, snakes and insect pests.

For production of vegetables, it is important to clean the area intended for planting at least a month before to remove weeds and grasses. This practice can help to prevent pests and diseases from infecting the new crops.

Integrated Weed Management (IWM):

- IWM: use of a combination of different practices to maintain weed densities at manageable levels.
- IWM approach to land management combines the use of complementary weed control methods such as herbicide application, land fallowing and biological control.
  (FAO, 2009)

In a vegetable garden, weeds can be controlled mechanically, culturally or chemically.

4.7.1 Mechanical weed control

Weeds are removed by means of ploughing or pulling them out by hand or by using a hand hoe, before planting and during the growing period.

4.7.2 Cultural weed control

Cultural weed control includes:

- Using other plants through (i) crop rotation, (ii) intercropping, and (iii) fallow period
- Mulching: This is very efficient in controlling of weeds, although this is not its primary purpose (see Section 4.9.3).
- Boiling water: Pour boiling water over weed plants to control small patches of weeds in gardens.
- Allelopathy is the regulation of weeds by increasing the competitiveness of crops over co-existing weeds. An example is the release of toxic substances into the environment by crops such as rye, barley, wheat, tobacco and oats, either through root exudatio from decaying plant material that may inhibit the germination and growth of some weed.

4.7.3 Chemical weed control (using herbicides)

Chemical weed control minimizes labor and can be very effective if used with care. The critical point is to choose a herbicide that will remove the weeds without harming the crops.

Types of herbicides

- Non-selective herbicides will kill most plants including the cultivated crop. They must be sprayed on the field before planting.
  Selective herbicides are usually used for soil or foliar applications. They kill almost all other plants and leave the crop being protected.

Precautions when using herbicides

- Do not use a herbicide unless the label states that it is registered for that particular crop. Be sure to use as directed on the label
- Use a boom and nozzle arrangement that will fan out the material close to the ground
- Thoroughly clean spray tank before and after use
- Wash hand after using the herbicides, even if you were wearing the gloves
- Do not harvest crops for eating after applying the herbicides, observe a recommended waiting period

4.8 Irrigation

Irrigation of crops is key for successful gardening. When an irrigation system is selected it is very important to make sure it is the best system available for the specific situation. The Types of irrigation systems include :

- Permanent systems (drip, micros and permanent sprinkler systems)
- Moveable systems (drag line & overhead sprinklers) which can be moved by hand
- Hosepipes and furrow irrigation are often used for surface irrigation

4.8.1 Soil moisture

After rainfall or irrigation, all the soil pore spaces are filled with water and if the rain or irrigation continues the surface pooling or runoff occurs. The rate at which a soil can absorb water is influenced by its texture and structure. All sands and loamy sands tend to have a low water holding capacity while clay loams have high water holding capacity.

4.8.2 Watering techniques

Food crops need a steady supply of water from time of planting until harvest. Giving plants too little water in their root zones will result in wilting and if not remedied, eventual death. Giving plants too much water may drown roots, causing plants to stop growing or die.
It is advisable to water early in the morning or late in the afternoon when the evaporation rate is lower. In areas where frost occurs during winter care should be taken not to irrigate late afternoon as this can lead to extensive cold damage on the plants.

Seedlings with small shallow roots need to be watered two or three times a day. A well established (mature) crop can be watered once a day.

4.8.3 Water requirements of vegetable crops

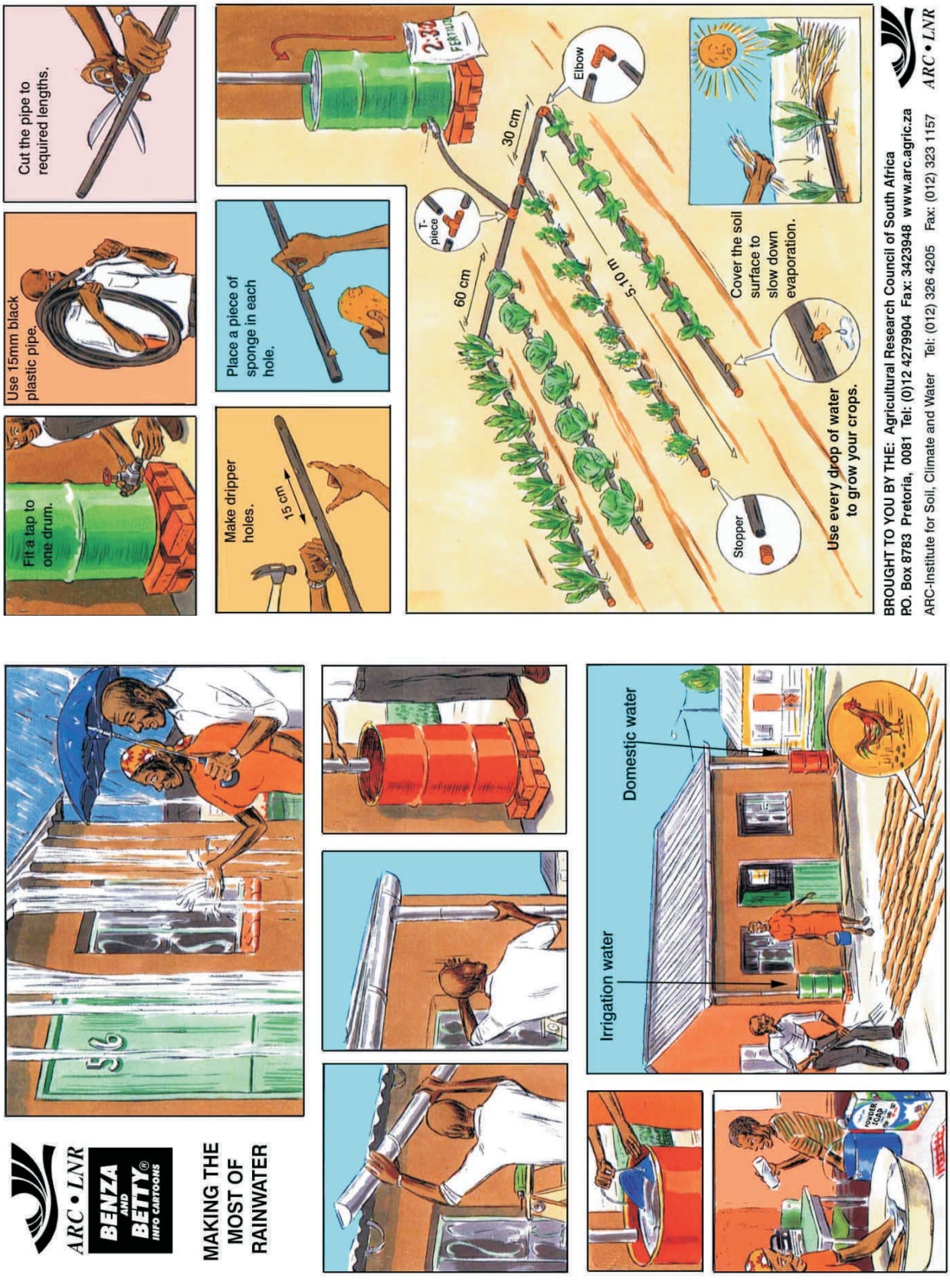
The following are only general guidelines and should be adapted according to the season and circumstances on your own plot or garden:

Seedlings	Water between sowing and emergence of the seedling. The soil that is in contact with the seed must at all times be moist
Transplants	Watering before and after transplanting is essential, particularly in hot weather
Leafy crops	Cabbage family crops and spinach require about 25 L per square meter a week
Root crops	e.g. potatoes, carrots, sweet potato require 10 and 15 L per square meter weekly, during the first month after planting. Thereafter 30 L per square meter will be adequate.
Other crops	e.g. legumes, cucurbits, tomato require 25 L per square meter but varies according to the stage of development.
Water efficient vegetables	e.g. cowpeas, amaranth, pigeon peas and bambara are known to be drought tolerant and can be grown under rain fed conditions if the rain is well distributed.

4.8.5 Water harvesting

(a) Rain water harvesting

Below it is explained how to collect rain water from the roofs of buildings into tanks:



In field rain water harvesting

The aim is to transfer run-off water from a land area that is not planted to supplement rainfall received directly on the area where crops are grown (FARMESA, 2005).
There are two types of catchment areas:

i) Catchment strips within the boundary of the cultivated area are altered to direct run-off water to cultivated plots.

ii) Catchment in external area (e.g. play ground; paths, roads) and diverted to cultivated area Considering the gradient of the school grounds dig trenches to direct water to flow to the garden. This method is not suitable on shallow soils and in areas prone to land slides.

In the case of large school grounds, water from the trenches can be collected into simple dam structure and from there used for furrow irrigation.

4.8.6 Mulches

Mulch can be defined as a thick layer (about 10 cm) of organic material spread over the otherwise bare soil, and usually placed after planting. They can be made from several materials such as lawn mowing, straw, wood shavings, sawdust, newspaper and plastics.

Advantages of mulches:

- Regulate soil moisture and temperature
- Enhance water absorption
- Prevent soil erosion
- Suppress weeds

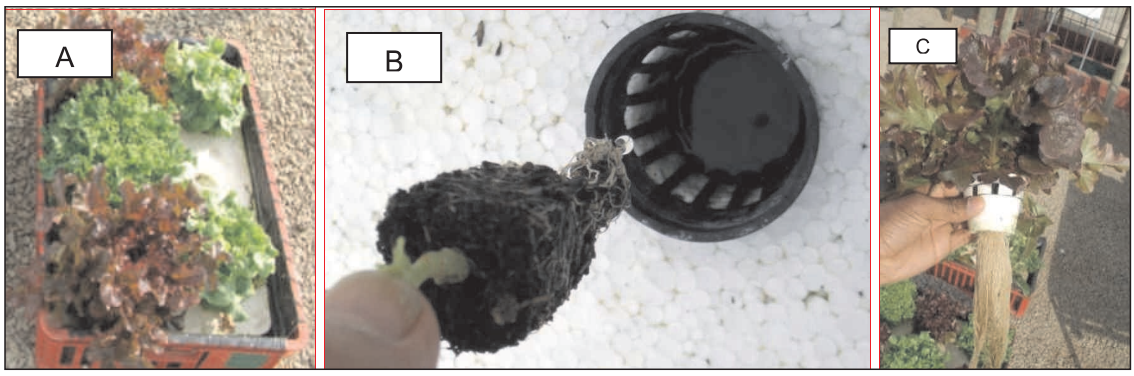
4.9 Hydroponic production

Hydroponics (soilless culture) is a crop production system where plants are grown in an artificial medium other than natural soil. All the nutrients are dissolved in the irrigation water and supplied on a regular basis to plants.

The most common hydroponic systems used in South Africa is the open system, where crops such as tomatoes, cucumbers, and green peppers are produced. The second is the closed (recirculating) system, of which the gravel film technique (GFT), are the most popular for cultivation of leafy vegetables such as lettuce and spinach.

4.9.1 Small-scale hydroponic production system

A feasible system for both school gardens and home gardens is a non-circulating hydroponic system which operates without electricity. Other systems require electricity for a pump which circulates water. In this case crops (e.g. leafy vegetables such as baby spinach and leafy lettuce) are grown in rectangular flat buckets with nutrient solution. The seedlings are transplanted into polystyrene cups, with a small opening of 2 - 5 cm diameter, which fit into holes in a polystyrene sheet. The polystyrene cover floats on the nutrient solution in the bucket. The lower part (1 - 2 cm) of the cups is immersed in the nutrient solution. The upper part of the roots should be exposed to air while the lower part of the roots is in contact with the nutrient solution.



An affordable non-circulating hydroponic system operating without electricity: (A) kept in crates; (B) Netted cups, and C) lettuce in a netted cup.

5. FACT SHEETS ON VEGETABLES & HERBS

5.1 Vegetables

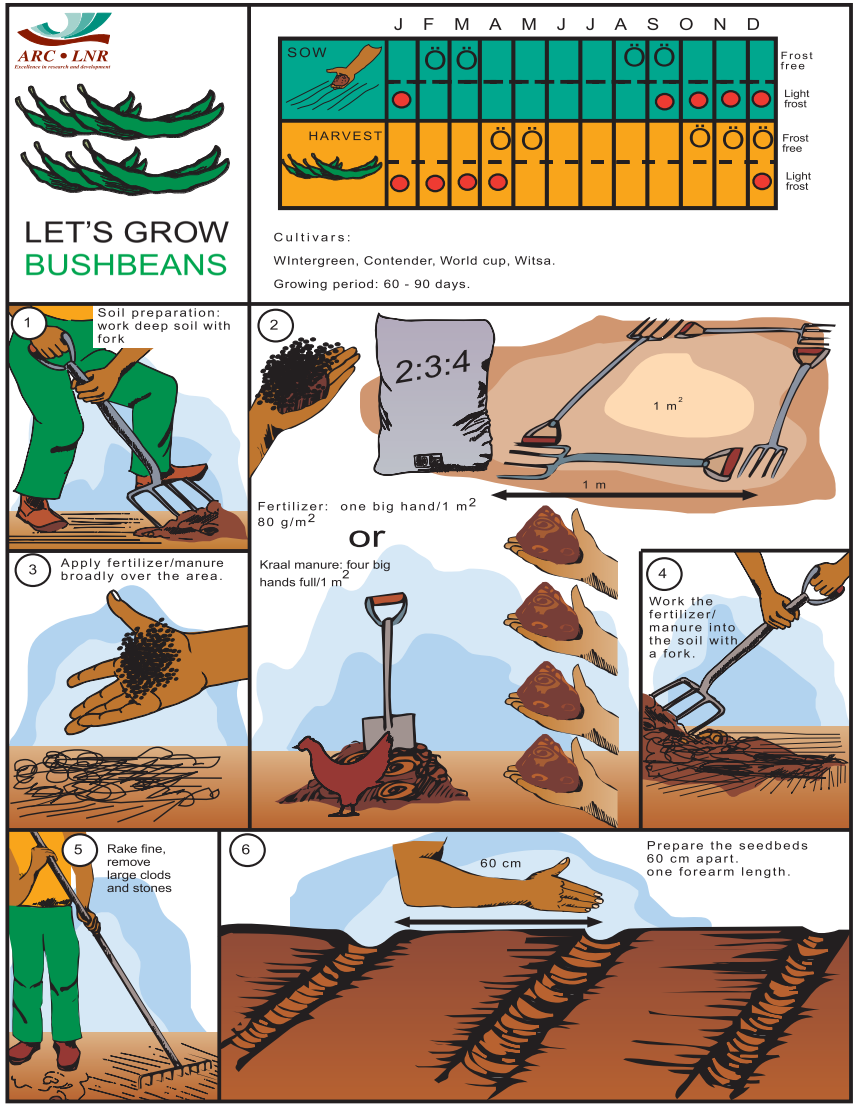
BEANS

Green bean (*Phaseolus vulgaris*) is 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 B_2) to the human diet. Green beans are a tropical crop and consequently sensitive to low temperatures. In general farmers plant both bush as well as runner varieties.

Local names:
Sesotho: Dinawa **Sepedi**: Dinawa **Setswana:** Dinawa **IsiNdebele :** Amabhontjisi
isiXhosa: LImbotyi **Tshivenda**: Nawa **isiZulu:** Ubhontshisi **siSwati:** Emabhotjisi
Xitsonga: Tinyawa

SOIL	Green bean can be successfully cultivated in soils, which range from sandy to reasonably heavy clay soils. The crop prefers deep, well-drained soils, with good water retention ability. The best results are achieved in medium loam soils. A soil pH of 6.0 to 6.5 is recommended.
CLIMATE	Because of its tropical origin, green bean cannot be successfully cultivated in areas with temperatures below 10°C. The optimum temperature is between 16°C and 24°C.
CULTIVARS	Bush bean: Wintergreen, Contender, Class Act, World Cup, Imali, Malelaan, Star 2000, Star 2052 Runner bean: Witsa, Lazy Housewife
CROP ROTATION	Rotate with other crops to avoid transmission of diseases such as bacterial blight, anthracnose and Fusarium-wilt. As a result of their nitrogen-fixing ability, legumes (such as bean), builds up the soil nutrient status.
PROPAGATION	Bean establish well with direct sowing.
SPACING	The optimum spacing for bush beans is 60 cm between rows and 5 cm between plants in a row. For runner bean a wider spacing is used: rows 1 m apart and plants spaced 10 cm apart in the row. To save cost on trellising, 3 plants can be trellised to one support.

PLANTING TIME	**Production Area**	**Planting time**
	Highveld (heavy frost in winter) of Gauteng, North-West & Mpumalanga.	Middle September to January
	Middleveld (light frost in winter) of Gauteng, Northern Province, Mpumalanga & KwaZulu/Natal.	September to February.
	Lowveld (cooler areas of Mpumalanga, Northern Province & KwaZulu/Natal).	August to September & February to March.
	Lowveld (with very hot summers & frost-free winters) of Mpumalanga, Northern Province & KwaZulu/Natal.	March to August.
FERTILIZATION	General fertilizer recommendation: 100 g/m^2 of 2:3:4(27) applied and worked into the top 10 cm of the soil. After planting, apply a top dressing of 10 gram LAN/m^2 at 2 and again at 4 weeks. Organic fertilizers applied before planting (compost or manure at 4 handfulls/m^2).	
IRRIGATION	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.	
HARVESTING	Beans generally take 60 – 90 days to mature. Repeated harvests when the pods are still young, will induce the formation of new flower buds and as a result a higher yield of young pods. Beans ripen very quickly in warm weather and therefore it is necessary to harvest every day to get good quality pods.	
PESTS	Bean seed beetle, bean seed maggot, CMR-beetle, brown beetle, thrips, African bollworm, plusia looper, tip wilters, aphids, red spider mites. Control: Scout regularly. Consult your agricultural supply outlet for pesticides. Insect repellent sprays e.g. onion and garlic spray may help to keep pests at bay. Spray aphids with light liquid soap water. Root knot nematodes. Control: Leave the soil fallow for a period of time. Practice crop rotation - cropping with marigolds, castor beans etc. Soil solarization. Use registered nematicides.	
DISEASES	Bacterial blight, anthracnose, ashy stem blight, Fusarium root rot, Rhizoctonia root rot, rust, scab, sclerotinia stem rot. Control: Use disease-free seed. Practice crop rotation and sanitation. Chemical control. Plant in well-drained soil. Rust resistant cultivars are available. For Rhizoctonia root rot a pre-plant chemical drench can be considered. Chemical seed treatment controls Fusarium root rot. Bean mosaic virus, yellow mosaic viruses, necrosis viruses Control: Disease-free seed. Control aphids.	



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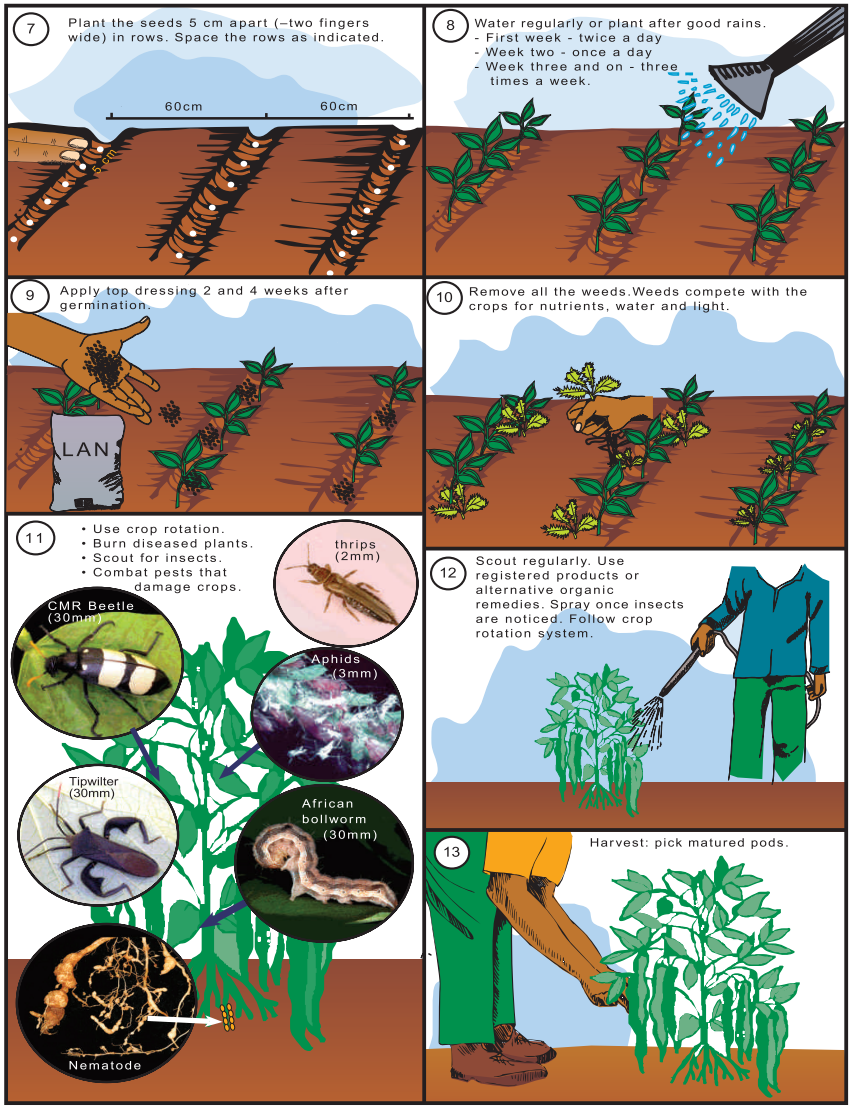


ARC-Roodeplaat Vegetable and Ornamental Plant Institute / Tel: 012 841 9611.

BEETROOT

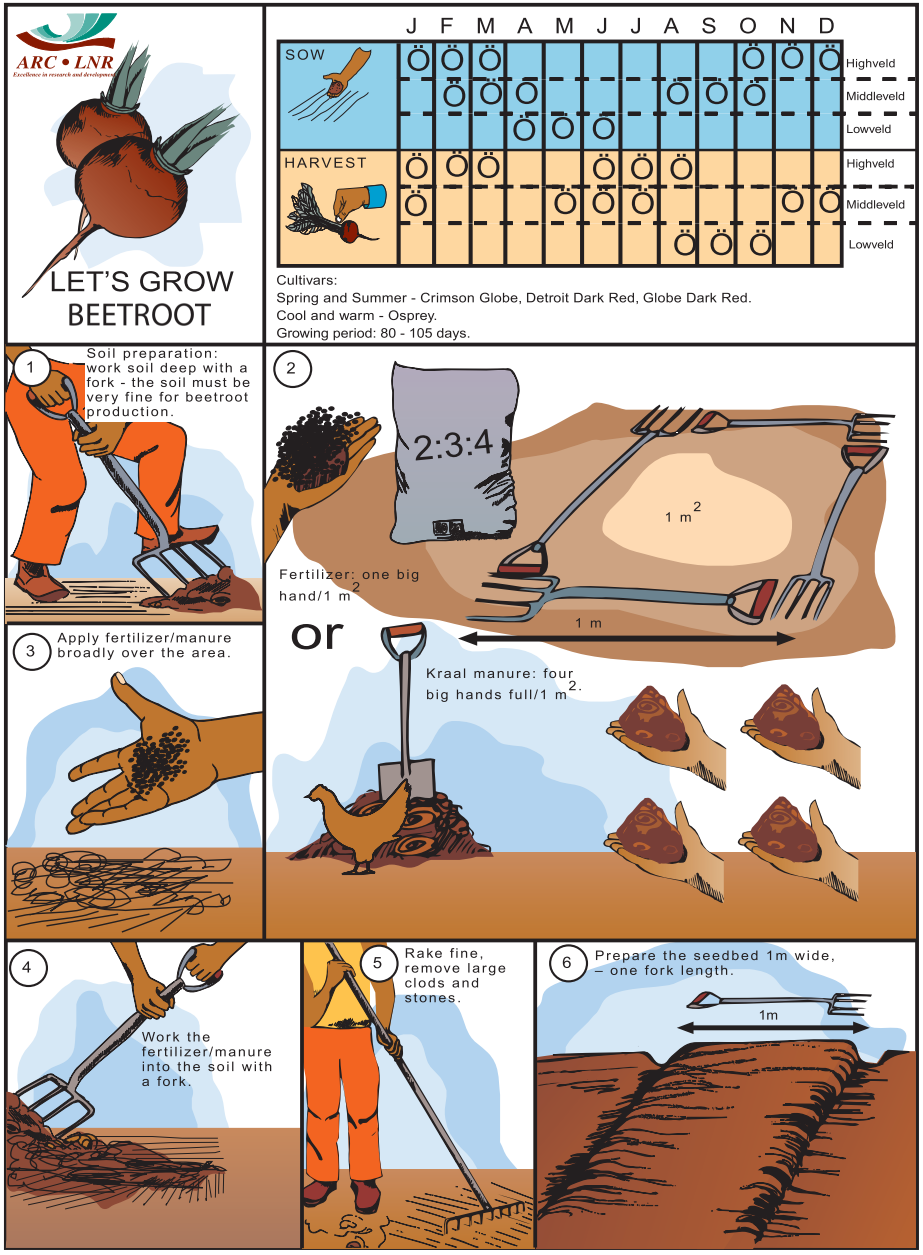
Beet (*Beta vulgaris*), also known as beetroot or red beet, is a versatile vegetable: it can be eaten, cooked or as a side dish or as relish. Both the storage root and young leaves are used. Beet tops are cooked as greens. It belongs to the same family as spinach. The crop is a cool season crop but can grow well even under warm weather. Fresh beetroot is available all year round on local markets. The colour of beet is due to high concentrations of anthocyanin; the more concentrated the anthocynins, the darker the colour. Anti-oxidants are important in immune response to fight infection. Beet leaves is also a source of folate and iron.

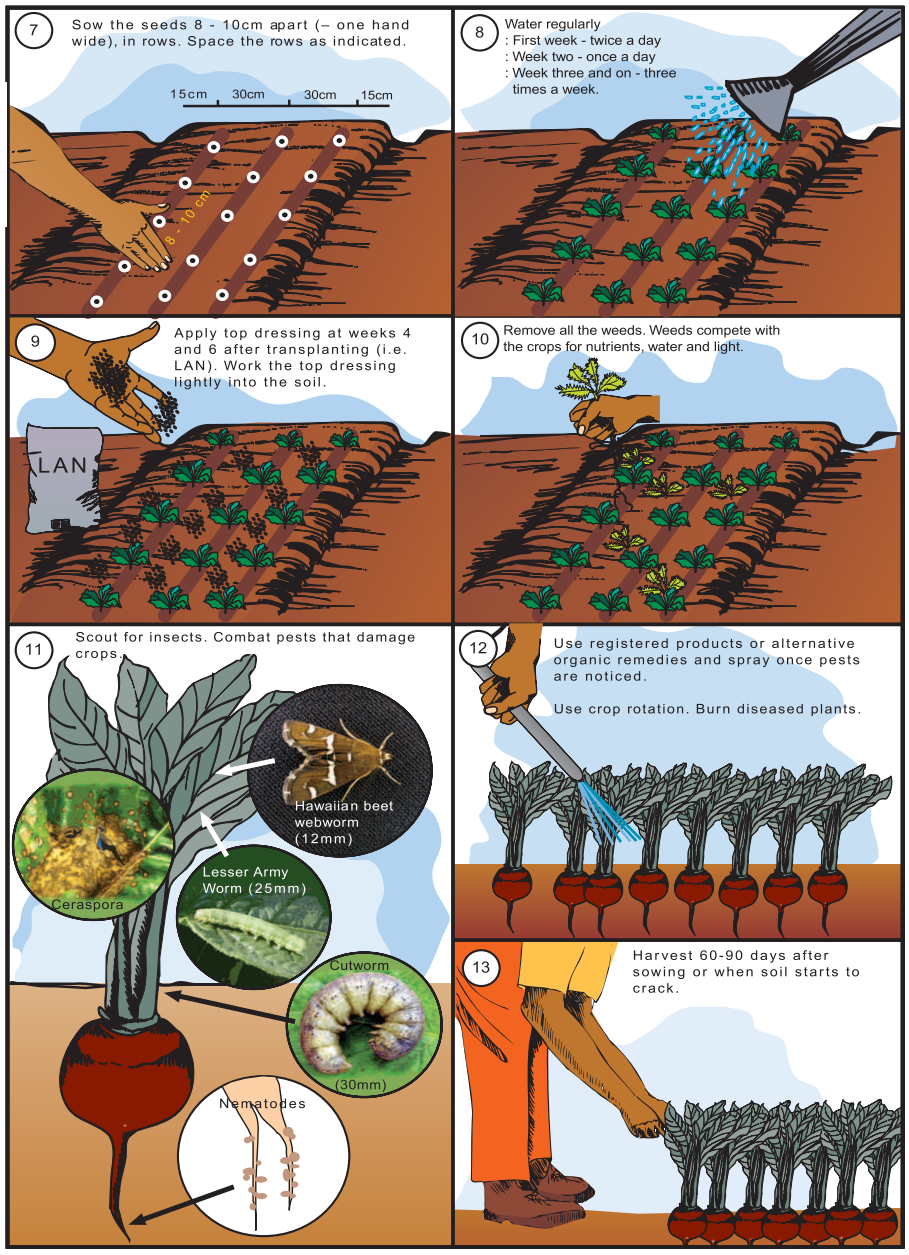
Local names:

Sesotho: Betiruti **Sepedi:** Petiruti **Setswana :** Betiruti **IsiNdebele :** Ibhethirude
isiXhosa: Ibhitiruti **Tshivenda:** Beetroot **isiZulu:** Beetroot **Xitsonga:** Bitiruti

SOIL	Sandy loam and loam soils are optimal for successful beetroot cultivation. Avoid soils where compost was recently incorporated into the soil since it will promote the formation of side roots. A soil pH of 6.0 to 7.5 is recommended.
CLIMATE	Beetroot is a cool weather crop. It also grows well during warm weather but quality is better under cool conditions. Plants are not killed by frost but growth is slowed down.
CULTIVARS AND PLANTING TIME	Spring & Summer: Crimson Globe, Detroit Dark Red, Star 1105, Merlin, Globe Dark Red Summer and Winter: Osprey. Winter: Early Wonder
PROPAGATION	The seed appears to be corky and fairly big. It is in fact a small fruit which contains two to six seeds. One fruit/seed can therefore give rise to more than one seedling. Beetroot are often established with seedlings, but can also be sown directly.
SPACING	In-row spacing of 8-10 cm and between rows 25-35 cm. If planted in beds, the spacing can be 10 cm x 10 cm.
FERTILIZATION	General recommendations: Prior to planting, a dressing of 100 gram per square meter 2:3:4 (27) may be regarded as a minimum to ensure that the plants get a good start. A top-dressing with LAN is necessary at 4 weeks. Apply 12 g LAN per meter row (6 g on each side).
IRRIGATION	Beetroot needs 30 mm of water per week. In the early stages of growth, less water can be applied.

HARVESTING	The beetroot reach maturity (25 to 40 mm in diameter) after 2½ to 3 months in summer, but in winter it takes 3½ to 4 months. Harvesting may continue selectively over several weeks. Young leaves can be harvested and cooked like spinach. The cultivar Crimson Globe is suitable for harvesting of leaves.
PESTS	Cutworm, Hawaiian beet webworm, lesser armyworm. Control: Scout regularly. Consult your agricultural supply outlet for pesticides. Insect repellent sprays e.g. onion and garlic spray may keep pests at bay. Cutworm is controlled by keeping the field free of weeds for 6 weeks before planting and applying cutworm bait. Nematodes. Control: Leave the soil fallow for a period of time, practice crop rotation (cropping with marigolds, castor etc.), soil solarization. Use registered nematicides.
DISEASES	Cercospora leaf spot, downy mildew, root rot, damping – off. Control: Chemical treatment of seed. Practice crop rotation and sanitation. Plant in well-drained soil. Don't over-water.





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CARROT

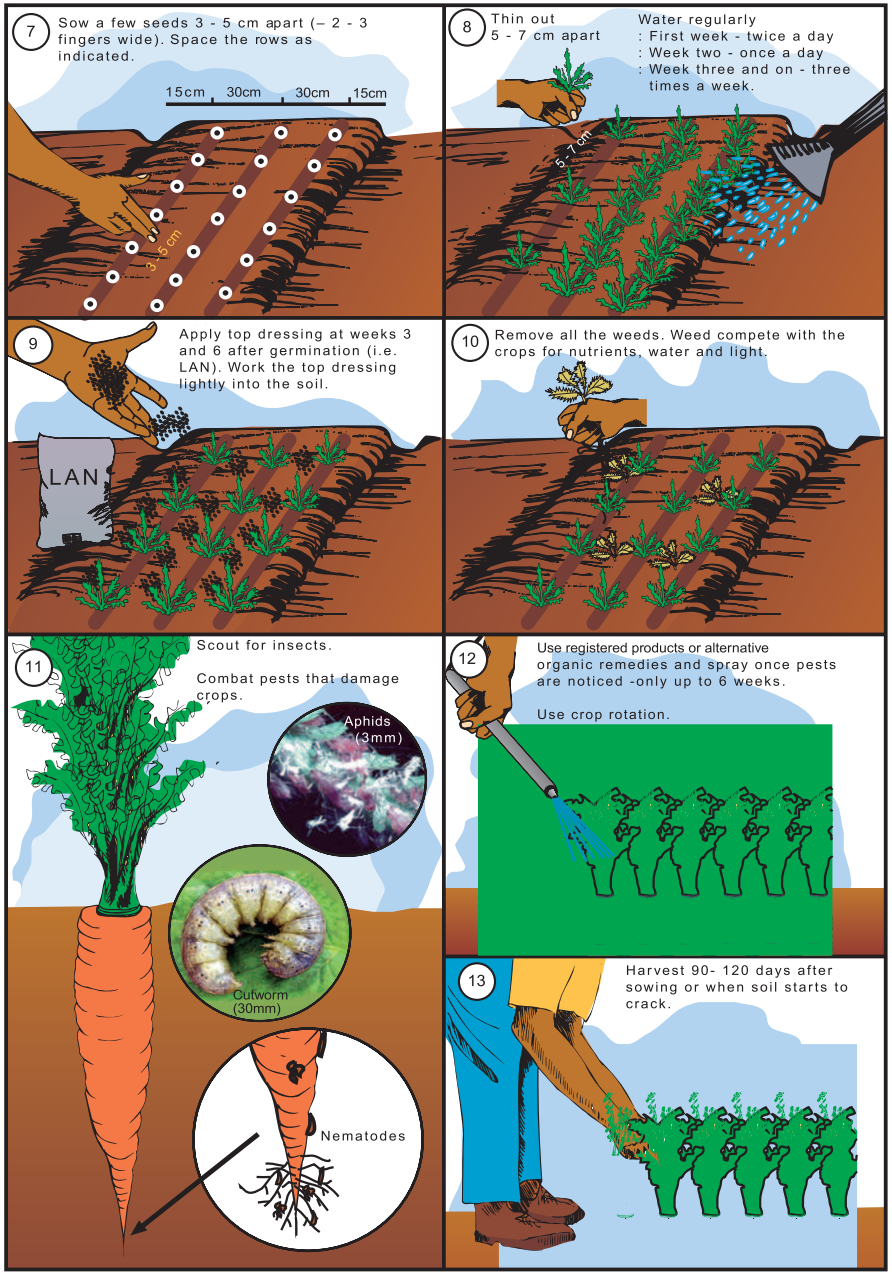
Carrot (*Daucus carota*) is indigenous to Asia and Eastern Europe and belongs to the *Apaceae* family. Carrots are important root crops, both in commercial and home gardens throughout South Africa. The crop is grown for its root, which can be eaten cooked or raw. Carrots are particularly rich in beta-carotene (vitamin A). The crop grows well in cool growing conditions as long as there is enough moisture and is fairly resistant to frost.

Local names:

Sesotho: Kherote **Sepedi**: Kherotse **Setswana:** Segwete **IsiNdebele:** Isikwende **isiXhosa:** Umnqathe
Tshivenda: Kheroti **isiZulu:** Ukheloti **siSwati:** Likhelotsi **Xitsonga:** Kherotso

SOIL	Deep, well-drained sandy loam to sandy soils. Soil texture is a very important factor, affecting the production of smooth, well-shaped roots. Soils, high in fresh organic matter can result in hairy and forked roots.
CLIMATE	Carrot is a cool weather crop. However, growth slows down if the temperature goes below 10ºC. Severe frost can damage the leaves.
CULTIVARS	Spring: Kuroda, Ideal Red, Javelin Autumn: Scarlet Nantes, Fancy, Flacoro, Kuroda
CROP ROTATION	Can be rotated well with cabbage, lettuce, pumpkins and tomato. Leguminous crops such as peas and beans in the rotational cropping with carrots improve the soil nutrient status.
SOWING TIMES	Highveld: August to mid-March. Middleveld: August to mid April. In very warm areas August to September and February to March.
SOIL PREPARATION	All clods should be crushed by using a rake until a deep fine bed is obtained. Remove stones because it can cause poorly shaped carrots. All the weeds should be removed before sowing. Cover crops can be planted and worked into the soil 3-4 months before establishing the crop.
SOWING METHOD	Carrot is planted directly and must not be transplanted. Make holes 1.5 cm deep 3-5 cm (2-3 fingers) apart. When sowing, put the seed into the palm of one hand, taking a substantial pinch of seed with the other hand and rubbing it between the finger and the thumb forward and backwards to place a few seeds in each hole. Another method is to mix one teaspoon of seed with 10 teaspoons of sand and sow it. Seed should be covered with a fine soil and should be mulched with dry grass to keep the soil cool and moist. Emergence may take 7-14 days depending on the cultivar, weather, soil type and the season.

SPACING	30 – 35 cm between rows. Thinning is done at approximately 2 weeks after emergence when the carrot seedlings are about 4 cm high and again at 4 weeks. This should result in a spacing of 5 - 7 cm.
FERTILIZATION	General fertilizer recommendations: 100g/m^2 of 2:3:4 (30) + Zn or 110g/m^2 of 2:3:2 (22) + Zn are broadcasted before planting and worked into the top 10cm of soil. Apply LAN 10 g/m of row at 3 and 6 weeks after emergence. Apply at a distance of 5 cm from the plants, at both sides. Work into the top 2 cm of the soil with a trowel. Do not use manure and compost for carrots. This causes malformation of roots thus decreasing the marketable yield. Nevertheless, manure can be applied for the crop preceding the carrot.
HARVEST	Carrots take 10-12 weeks to reach maturity. They can be harvested as soon as they reach a diameter of 20 mm. They are harvested by pulling the tops by hand or by loosening them with a fork and pulling the tops. When digging, you should start some 15 cm away from the base of the plants. Do not harvest early in the morning in cold soils as it may cause the roots to crack horizontally.
PESTS	Cutworm, aphids, carrot fly. Control: Scout regularly. Consult your agricultural supply outlet for pesticides. Insect repellent sprays e.g. onion and garlic spray. Cutworm bait. Nematodes. Control: Leave the soil fallow for a period of time. Practice crop rotation - cropping (with marigolds, castor beans etc), soil solarization, use registered nematicides.
DISEASES	Alternaria leaf blight, bacterial leaf blight, southern blight, cottony rot. Control: Practice crop rotation, plant in well-drained soil, do not over-irrigate, remove and burn infected plants. Control weeds in and around fields remove plant residues from the field after harvesting. Note: No disease control chemicals are registered for carrots.



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CABBAGE

Cabbage (*Brassica oleracea*) is a very popular vegetable in South Africa. People use cabbage in different ways, cooked and eaten with porridge, mixed with meat, added to stews or in salad. Cabbage is a good source of dietary fiber.
It is a cool season crop, but new cultivars are extending the seasonal range in which it can be successfully grown. It is easy to grow, but one should control the pests and diseases throughout the growing period. Specific cultivars should be selected for different production seasons since some cultivars are better suited for summer production than others.

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Local names:
Sesotho: Khabetshe **Sepedi**: Khabetshe **Setswana:** Khabitshe **IsiNdebele:** Ikhabitjhi **isiXhosa:** Ikhapetshu
Tshivenda : Khavhishi **isiZulu:**Iklabishi **siSwati:** Likhabishi **Xitsonga:** Khavichi

SOIL	Cabbage can be grown in virtually all types of soil. The crop can be grown successfully in sandy loam to clay loam soils with high organic matter content. The soil should be well drained. A soil pH of 6.5 to 7 is recommended.
CLIMATE	Cabbage is a cool weather crop. It is fairly resistant to frost and can survive temperatures as low as –3 ^{0} C. It can be grown throughout the year in most areas, but does not do well in the summer months in the Lowveld where the summer months are very hot and humid.
CULTIVARS AND SOWING TIMES	Sowing period: - Spring and late summer: Tenacity, Conquestador. - Late summer (Jan-Feb): Hercules, Drumhead, Grand Slam. - African Sun (Late summer) (all year in mild areas). - Late summer to autumn: Megaton (cold tolerant)(harvest in spring).
CROP ROTATION	Rotate cabbages with crops such as tomatoes, pumpkins, sweet potatoes, beans, peas, melons, potatoes or maize. Cabbage is a heavy feeder (high requirement for soil nitrogen) and must be planted after legume crops.
SOWING METHODS	Cabbage is established from seedlings. Prepare a fine seedbed to produce seedlings. Make shallow furrows 15 cm apart a finger nail deep (1.5 cm) and sow seed 5 cm apart in the row. After sowing cover the seeds with light soil and mulch. The seedlings should be ready for transplanting 4-5 weeks later. The harvesting periods can be extended by seeding different cultivars.
SPACING	Cultivars with big heads need more space than cultivars with small heads. Small head cultivars: 30 cm in row x 50 cm between rows.

PLANTING METHODS	Water the bed before transplanting. Remove the seedlings from the seedbeds with soil on the roots. Make holes and transplant the seedlings in the holes. Plant the seedlings a little bit deeper than they stood in the nursery. Press down the soil around each plant but not too close to the plant stem. Plant in wet soil and water the plants immediately after transplanting. Transplant during morning hours (preferably on cloudy days) or late in the afternoon.
FERTILIZATION	At transplanting a side dressing of about 12g/plant of 2:3:4 (30) is necessary to ensure that the plants get a good start. A top dressing of nitrogen LAN 28% N at 21, and 35 days after transplanting especially on sandy soils. Nitrogenous fertilizer should not be applied later than six weeks after transplanting because the head may crack open. Start with 4g per plant and later 10g per plant. Apply at about 15 cm around plants and water well after each application.
IRRIGATION	Sufficient water is critical especially immediately after transplanting. It is also important that young plants receive enough water for vegetative growth before forming heads, since the bigger the plant at this stage, the larger the eventual head will be. Cabbage requires approximately 35 mm irrigation per week. Too much water once the heads have formed can cause them to crack.
HARVESTING	90 – 140 days after transplanting, depending on the climate and cultivar. Cabbage heads must be pressed with a thumb to test for firmness. Cut with a sharp knife when the heads are firm and hard. Harvesting may continue selectively over several weeks. Store in cool shaded place, keep 2 – 3 non-heading leaves for protection during transporting.
PESTS	Aphids, bagrada bugs, diamond back moth Control: Regular scouting. Window-like patches in leaves reveals presence of diamond back moth larvae. Consult an agricultural supply store about chemical control. Nematodes. Control: Leave the soil fallow for a period of time, practice crop rotation (marigolds, castor, beans, etc), soil solarization, use registered nematicides.
DISEASES	Black rot, downy mildew, club root, white rot, bacterial leaf spot, black leg Control: Practice a 3-4 year crop rotation. Do not water in the evening, water early in the day so that leaves can dry before night fall. Try not to work in plantings when they are wet. Use disease-free transplants, remove and destroy infected plants, spray with registered chemicals.

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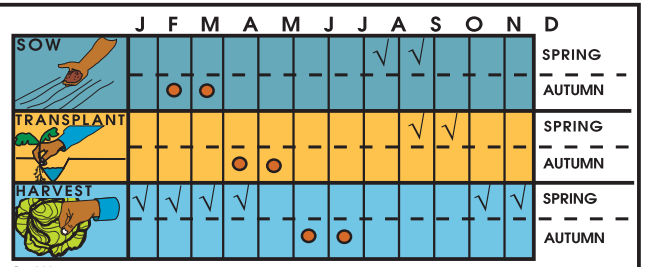
LET'S GROW CABBAGE



Cultivars:
Spring and Autumn - Tenacity, Conquestador.
Autumn - Hercules, Drumhead, Grand Slam.
Growing period: 90 - 110 days.

1 Soil preparation: work soil deep with fork.

2 2:3:4

1 m²

1 m

Fertilizer: one big hand/1 m²

or

Kraal manure: four big hands full/1 m²

3 Apply fertilizer/manure broadly over the area.

4 Work the fertilizer/ manure into the soil with a fork.

5 Rake fine, remove large clods and stones.

6 1m

Prepare the seedbed 1m wide, □ one fork length.

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7 Space the seedlings 50 - 70 cm apart (□ one forearm), in rows. Space the rows as indicated.

10cm 40cm 40cm 10cm

50 - 70 cm

8 Water regularly
: First week - twice a day
: Week two - once a day
: Week three and on - three times a week.

9 Apply top dressing at weeks 2 and 6 after trans-planting. (i.e. LAN). Work the top dressing lightly into the soil.

LAN

10 Remove all the weeds. Weeds compete with the crops for nutrients, water and light.

11 Scout for insects. Combat pests that damage crops.

Bagrada bug (7mm)

seedling

Aphids (3mm)

Diamond back moth (8mm)

Nematode

12 Use registered products or alternative organic remedies and spray once pests are noticed.

Burn diseased plants.
Use crop rotation.

13 Harvest when heads are firm (see sow chart).

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CUCURBITS

Pumpkins, squash, marrow, cucumbers, watermelons, and muskmelons are members of the vine crop family called cucurbitaceae, commonly referred to as **cucurbits.** Pumpkins (round, orange) and squash (other shapes and colours) contain potassium and beta-carotene (the precursor of vitamin A), and the seeds are rich in zinc. The flowers are mostly unisexual and the plants monoecious (male and female flowers are separated but are borne on the same plant).

Local names:Pumpkin

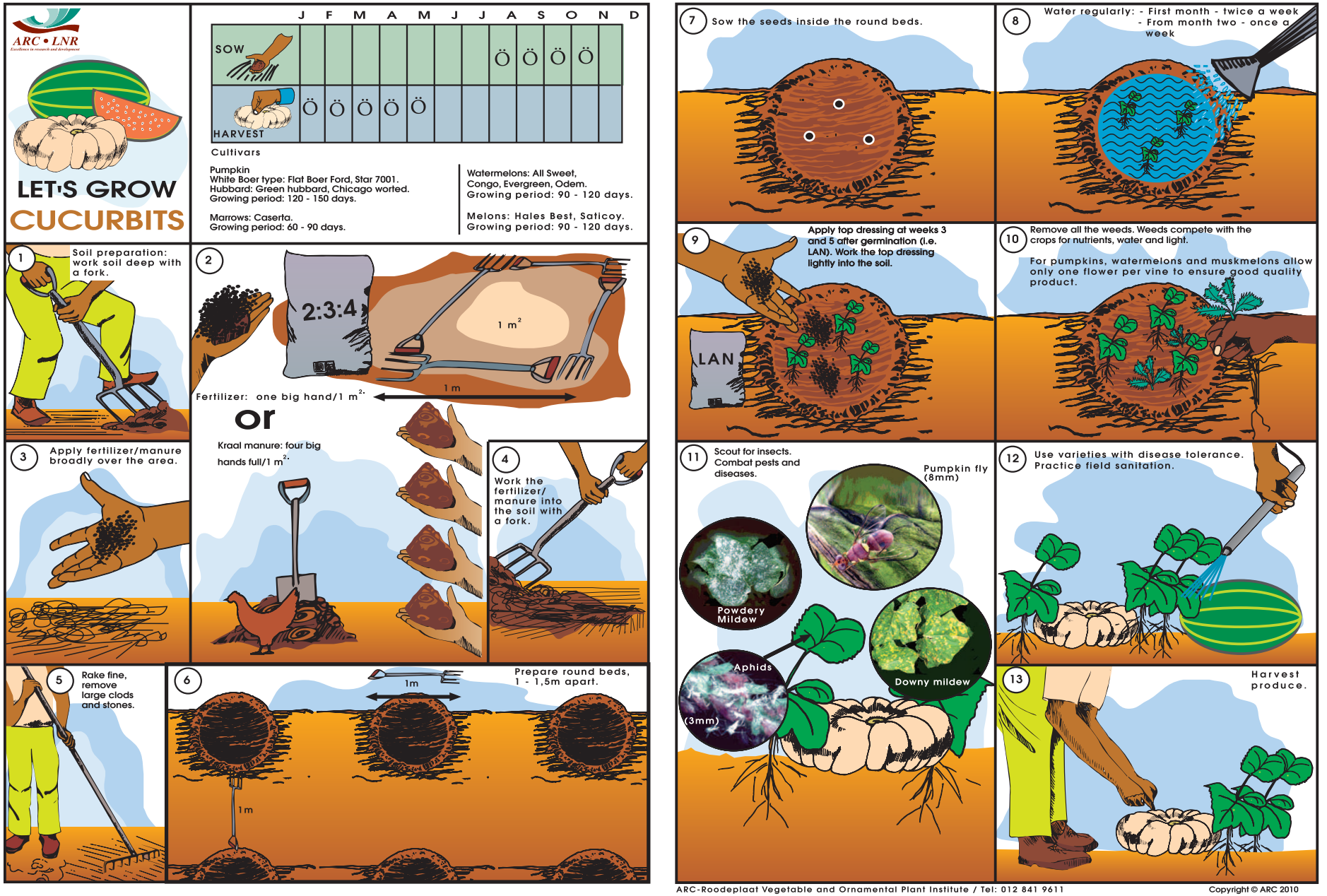
Sesotho: Lephutse **Sepedi:** Lefodi **Setswana:** Lephutse **IsiNdebele:** Umgade **isiXhosa**: Amathanga **Tshivenda:** Fhuri **isiZulu:** Ithanga **siSwati:** Litsanga **Xitsonga:** Shelotane

Local names:Butternut

Sesotho : Bathanate **Sepedi:**Lephutse labatanate **Setswana:**Batanate **IsiNdebele:** Ibhathanadi **isiXhosa:** Obathanathi **Tshivenda :** Tshifhuri/ zwifhuri **isiZulu:** Ubhathanathi **Swati:** Libhatanati **Xitsonga:** Kwembe

SOIL	The best results are obtained on loamy to sandy loam soils. Soil should be slightly acidic, but good results can be obtained over a pH range of 5.5 to 7.5.
CLIMATE	Cucurbits are warm-season crops and they grow best at temperature of 23-29ºC day and 15-21ºC night.
CULTIVARS	White boer type/Light grey pumpkin: Flat White Boer Ford, Star 7001, Star 7022 Queensland Blue, Crown Prince Hubbard: Green hubbard, Chicago worted Table squash: Table king, Table queen Butternut squashes: Waltham, Atlas
CROP ROTATION	Keep the area free from weeds by hoeing and shallow cultivation. Rotate cucurbits with crops from 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 three seeds are planted at the given distances within the rows.
SOWING TIME	September to November in mild areas and August to October in warm areas.
PLANTING METHOD	Cucurbit seed is planted 30 to 40 mm deep. Place 2-3 seeds per planting station, apart from each other. After 2 or 3 weeks when the plants are growing well, the seedlings are thinned to single plants.

SPACING	Pumpkins and melons are planted in rows 2 - 2.5 m apart, with plants spaced at 0.5 - 0.6 m. However, many growers use a 2 m x 2 m spacing to allow for intercropping. Squash/cucumber rows can be closer *viz*. 1 - 1.5 m apart.
FERTILIZATION	100 g/m^2 of 2:3:4 (27) must be band placed 40 cm wide. It must be worked into the soil very slightly just before planting. Compost or kraal manure may be used to supplement the chemical fertilizer. Apply a top dressing three weeks after transplanting or emergence, use 10 g KAN/LAN fertilizer per meter of row, 10cm from the stem. A second top dressing can be applied at 5 weeks.
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 the amount of water as fruits reach 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 cucurbits from the vines when they are mature. The best way is to leave a piece of the stalk attached. Avoid damaging the fruits when harvesting, because that can lead to a shorter storage life and disease problems. Estimated period to maturing: Butternut: 90-100 days; Pumpkin 120-150 days; Melons 95-120 days. The fruits can be cured by keeping them inside at room temperature for a week or two. Cucurbits require cool, fairly dry storage conditions.
PESTS	Aphids, pumpkin fly, cucurbit leaf beetles, nematodes Control: Scout for leaf beetles and control when first noticed in spring. Use registered pesticides (preventative control of pumpkin fly with Dipterex every 7-10 days when flowering starts). Field sanitation
DISEASES	Powdery mildew, downy mildew, Fusarium wilt, gummy stem blight/black rot, Phytophthora crown and root rot, angular leaf spot. Control: Tolerant varieties for Powdery mildew, downy mildew, Fusarium wilt, angular leaf spot. Consult an agricultural supply store about chemical control (essential for mildew). Avoid over-irrigation. Plant in well-drained soil. Practice field sanitation and crop rotation. Disease-free seed. Adjust pH to 6.5 to control Fusarium wilt. Cucumber mosaic virus (CMV), squash mosaic virus (SqMV), watermelon mosaic virus (WMV), and zucchini yellow mosaic virus (ZYMV). Control: Control insect vectors, remove infected plants, plant disease-free seed.



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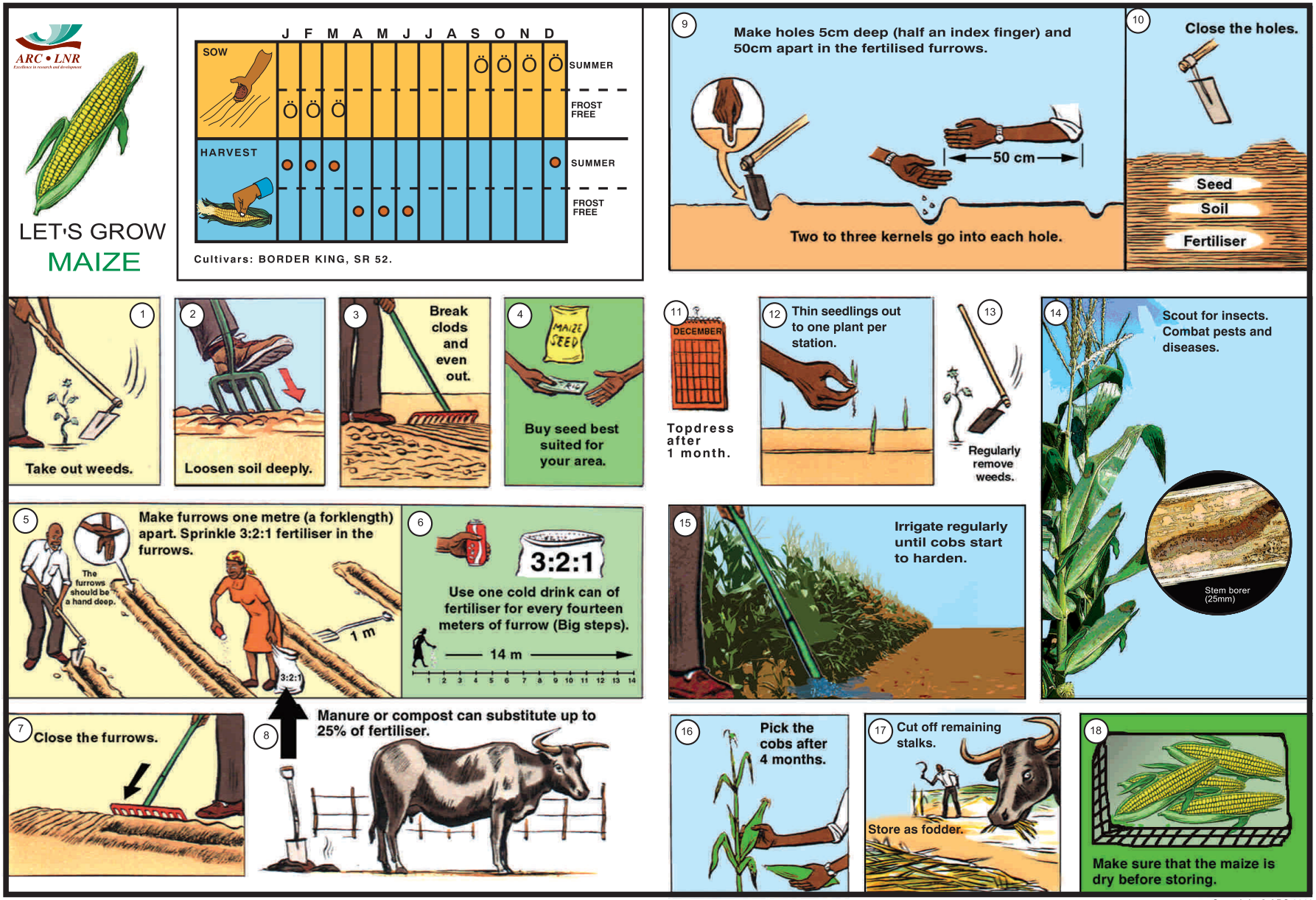
GREEN MEALIES

Maize (*Zea maize*) is the most important grain crop grown in South Africa. The green cobs can, however, be consumed as freshly cooked vegetables. Maize originated in south-eastern Mexico. Green mealies are a good source of carbohydrates and low levels of some vitamin and minerals. The protein content is low.
There are specific sweet corn varieties available.

SOIL	Maize is adapted to various soils from sandy to clay soil. The crop is susceptible to water logging, (especially when young) and prefer well drained soil.
CLIMATE	The crop is sensitive to frost and when grown as a summer crop in cold areas, planting should be only commence when night temperature rise above 10°C. In frost-free areas, green mealies can be used for summer and for winter production.
CULTIVARS	The following maize cultivars are available as green mealie cultivars. (Name of supplying company in brackets): SC701 (Agricol), CAP 775, CAP 341, Green Pearl and Sweet Pearl (Capstone). The following yellow sweet corn varieties are available: Jubilee and Contender.
CROP ROTATION	Rotate maize with legumes such as dry bean and soy bean. Green mealies can be rotated with most vegetables but avoid amaranth.
SOIL PREPARATION	Deep cultivate the soil to enable proper root development. Break clods and even out the soil.
PLANTING TIME	Summer production: September to December. Winter production (Frost-free areas): January to April
PROPAGATION	Green mealies are established with direct sowing. The soil must be kept moist until emergence (water daily for 1st week after planting) and hand weeding should be done on regular basis.
PLANTING METHOD AND SPACING	Make hand-deep furrow one meter apart and apply fertilizer in the furrow. Close the furrow with a layer of soil. Make holes-53 cm deep in the furrow and 30 – 40 cm apart. Sow two seeds per hole. Thin seedlings out to one plant per station at 2 weeks after germination. With certified seed only one seed per hole can be planted since the germination rate should be more than

	90%. At this planting rate the plant density can vary between 250 – 330 plants per 100 m^2. Where water is a limiting factor lower plant densities will reduce the risk of a crop failure.
FERTILISATION	Apply 3:2:1 (25) in the furrows before sowing seeds at a rate of one cold drink can per 14 m row. Apply top-dressing of 3-4 weeks after emergence at a rate of 25 g LAN (28) per m row. Any compost available from the home garden, should be applied. This practice will improve soil fertility and reduce the fertilizer requirement.
IRRIGATION	In general green mealies require 400 – 500 mm water during the growing season. It is important to water well after sowing to enable germination. Water the plants at least once every week and during hot spells twice a week for optimal growth and yield.
PESTS	Stalk borers are the most important pest that attacks the plant. Damage to the plants can be prevented by applying granular pesticides such as Dipterex (trichlorfon) or Bulldock (betacyflutrin). First scout the plants from an early stage. Then apply the pesticides to the whorl of the maize plant when small holes appear on the leaves.
DISEASES	Diplodia ear rot, maize streak virus and various leaf blights. Control: Use resistant cultivars. Control virus vectors such as leaf hoppers.
HARVESTING	Harvest green mealies at the early to late milk stage (about 4 months after planting). This stage is characterized by the white liquid, which fills the young maize kernel. The silks have usually just dried and turned a dark brown. It should be consumed as soon as possible after harvesting (2-3 days). The plant rests can be cut off for fodder.



ARC-Grain Crops Institute / Tel: 018 299 6100.

ONION

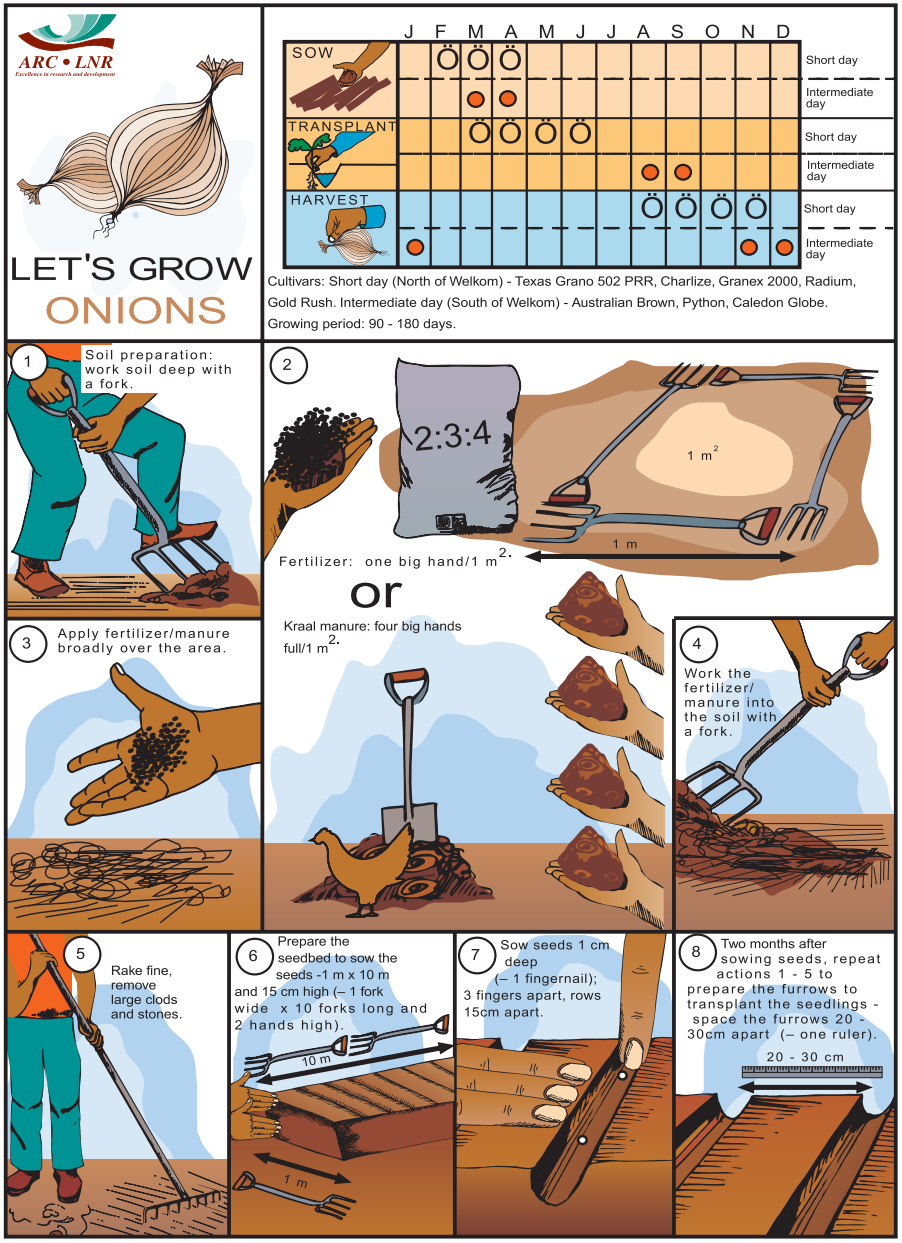
Onion (*Allium cepa* L.) has been used as food for centuries and is an important vegetable crop grown worldwide. It is used for flavoring food, both at the mature and immature stages, and used as salad and pickle. Bulb formation is triggered by both temperature and day length and specific varieties are adapted for specific production areas. It is important to plant a suitable onion variety at the correct time for your region. Onions are sometimes used as a repellent for insects on other vegetables.

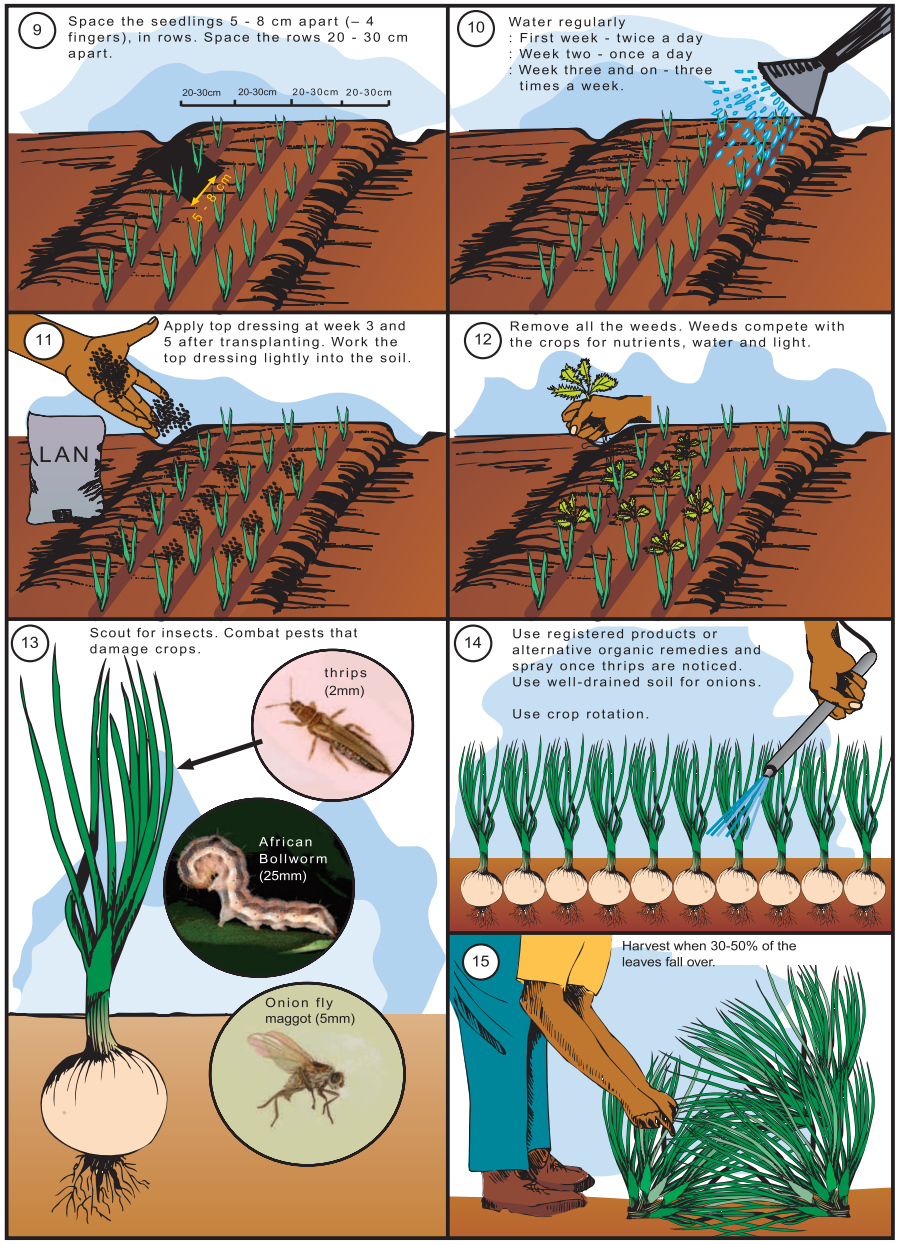
Local names:

Sesotho: Eie **Sepedi**: Eiye **Setswana:** Aiye **IsiNdebele:** Anyanisi **isiXhosa:** Itswele
Tshivenda: Nyala **isiZulu:** Unyanisi **siSwati:** Anyanisi **Xitsonga:** Nyala

SOIL	The best results are obtained on a loam soil that is fairly deep and well drained to a depth of about 120 cm. Onion grows best in soils with a pH of 5.5 - 6.5.
CLIMATE	The optimum temperature for growth is between 18°C and 22°C. Higher temperatures (25 to 27°C) speed up the bulbing process. Bolting (flowering) is triggered by low temperatures (8 to 13°C). Onions are sensitive to photoperiod. Bulbing is initiated once the light period exceeds a certain minimum requirement. Short day onions (grown north of Welkom) have a fairly short day length requirement. Intermediate day cultivars require longer day lengths for bulbing and are grown south of Welkom.
CULTIVARS	Short day cultivars: (northern areas): Texas Grano 502 PRR, Charlize, Mikado, San, Early Copper, Granex 2000, Hanna Red onions: Neptune, Red Creole Intermediate day cultivars: (southern areas): Australian Brown, Python, Semal, Caledon Globe
SOWING TIMES	<u>Short day onions</u>: Northern parts with cold winters — Feb-March Northern parts with warmer winters — March-April Free State and Northern Cape — Apr-May <u>Intermediate day onions:</u> Western Cape — Apr-May (transplanting in Aug-Sep)
CROP ROTATION	Rotate onion with non-related crops. Legumes like cow peas, beans and peas are recommended, because these crops also increase the soil fertility.
PROPAGATION	Onion can be sown directly, or seedlings can be made and transplanted later, or small bulbs (sets) can be planted. The best way for beginner farmers, is to transplant seedlings.

SEEDBED	Prepare a fine seedbed. Make furrows 15 cm apart from each other and sow seed at a depth of 10 - 15 mm. Sowing densities should be between 1 500 and 2 500 seeds per m^2. That is about 7g/m^2 of seed. Place mulch over the seedbed. Remove this when the plants start to emerge 7-14 days after sowing.
PLANTING METHOD	Seedlings of 8 - 9 mm in diameter (thickness of a pencil) and about 12-20 cm in height are ready for transplanting. Short day onions take about 6 - 8 weeks after sowing to be ready for transplanting. Prepare beds in the field of 1–1.2 m wide with paths of 0.5-0.7 m between beds. Spacing: Plant at 7-10 cm between plants and 20-25 cm between rows. Make furrows 2-4 cm deep and lay the white part of the seedling in the furrow. Use a rake or spade to cover the roots and compact the soil around the roots with the back side of the rake or by hand. Keep the soil moist (first 5 days) so that the plant can overcome the shock of transplanting and the root syste m to establish.
FERTILIZATION	General guidelines can be followed: During soil preparation work in 110 g/m^2 of 2:3:4 (27) or 100 g/m^2 of 2:3:4 (30). The crop is a heavy feeder of nitrogen and potassium. Onion use relatively high amounts of sulphur, therefore sulphur containing top dressing fertilizer like LAN (26.25 % N + 6 % S) should be used. Apply 10 g/m^2 LAN as well as 15g/m^2 potassium sulphate (K_2SO_4) 3 and 6 weeks after transplanting.
IRRIGATION	Onion requires approximately 400 - 600 mm of water during the growing season. Onion roots are concentrated in the upper 30 mm of the soil and therefore the soil must be kept moist, but three weeks before harvesting, no water must be applied.
HARVESTING	The growing period are 90-180 days depending on the planting time and area. Onions can be harvested when 100% of the leaves have lodged (fell over). Do not leave onion plants in the soil too long. Watering must be stopped three weeks before harvesting. The onions are lifted by loosing the soil with a fork. Make bundles and bind leaves together. Hang from the roof on the inside of a storeroom to dry. Once the neck of the bulb has completely dried, the leaves can be cut and the bulbs stored.
PESTS	Thrips, African bollworm, onion fly maggots Control: Practice crop rotation. There are chemicals registered for onion pests. Nematodes attack the roots and can be controlled by nematicides.
DISEASES	Downy mildew, pink root, purple blotch, white rot, fusarium basal plate rot. Control: Use disease-free seedlings, avoid over-irrigation and plant in well-drained soil. Plant cultivars tolerant to pink root. Practice crop rotation and field sanitation. Several chemicals are registered to use against diseases on onion.





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POTATO

Potato (*Solanum tuberosum*) is the fourth most important food crop in the world, after wheat, maize and rice. The tubers are rich sources of energy and contain vitamin C, fiber and minerals. It is also the second highest producer of protein (second only to soy beans). Potatoes are not only consumed by man, the produce are used extensively in industry e.g. starch, spirits and industrial alcohol. Potatoes may be boiled, fried (crisps and chips), baked, mashed and used in stews. They are also used as livestock feed.

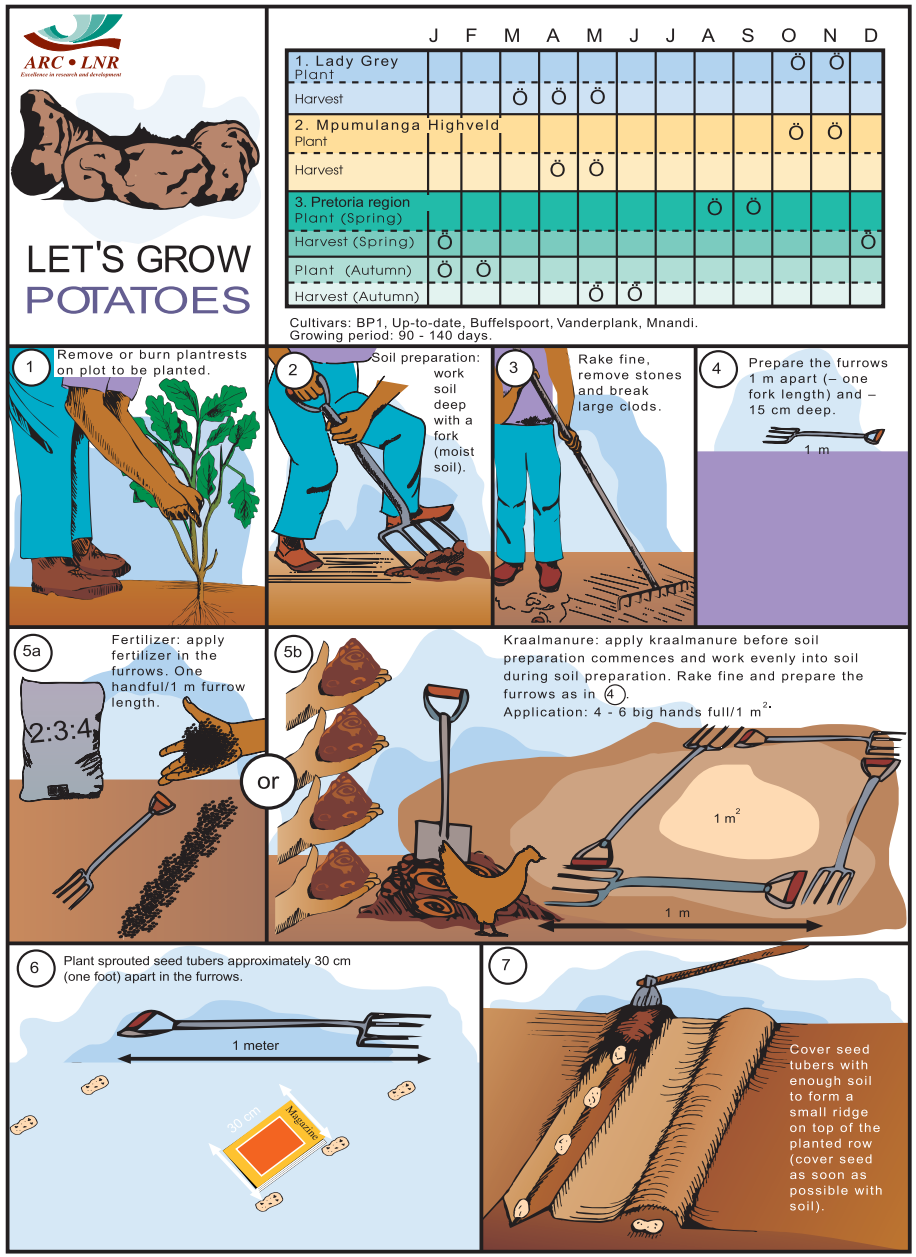
For detailed information see: Niederwieser, J.G. 2003. Guide to potato production in South Africa.

Local names:
Sesotho: Letapole **Sepedi:** Letsapane **Setswana:** Tapole **IsiNdebele:** Amazambane **isiXhosa:** Itapile
Tshivenda: Dabula **isiZulu:** Izambane **siSwati:** Lizambane **Xitsonga:** Zambala

SOIL	Most soil types are suitable for potato production, except heavy clay soils. Potato is adapted to a wide range of soil pH (5.0 – 6.5).
CLIMATIC	Potato is a cool weather crop and many potato cultivars do not yield well when temperatures are too high during periods when new tubers are initiating. Minimum temperatures higher than 19°C during initiation time can prevent tubers from forming.
CULTIVARS	Short grower (70-90 days): Vanderplank, Short-medium grower: Buffelspoort, Medium grower (90–110 days): BP1, Long growers (120–150 days): Mandi (Natal, Eastern Cape)
CROP ROTATION	Potatoes belong to the family Solanaceae together with tomatoes, brinjals, peppers, chilies and gooseberries and these can not be used in rotation with potatoes. Plant potatoes only after 4-6 years in the same field. Rotate with maize/grain crops, legumes, brassicas or onion.
SOIL PREPARATION	Deep till the soil and remove all compacted layers. The potato plant has a relative weak root system and is very sensitive to compacted soil layers. Irrigation lightly and prepare a fine seedbed consisting of a 15 cm deep layer of loose and finely crumbled moist soil.
PLANTING TIMES	**Production Area** — **Planting time** — **Harvesting time** Western Cape (late summer) — Jan-Feb — May-Jun (spring) — Sep-Oct — Dec-Jan

	Mpumalanga (Highveld) (Lowveld)	Oct-Nov Apr - Jun	Apr-May Aug-Oct
	Lady Grey area	Oct-Nov	Mar-May
	Pretoria area (spring) (late summer)	Aug-Sep Jan-Feb	Dec-Jan May-Jun
PLANTING METHOD	Seed tubers are used for planting potato. Potatoes should be planted when the soil is moist (irrigate before planting). Plant the tubers about 20cm deep in a furrow to which fertilizer has been applied. Close the furrow with the soil removed during the opening of the furrow and if the soil has dried out, irrigate lightly. Potato plants are ridged after they are well established (plants 20-25 cm high), to ensure that the developing tubers will be covered with enough soil to avoid sun damage and to protect them from attacks by pests and diseases.		
SPACING	Under irrigation a between row spacing of 75-100 cm, and without irrigation (rain-fed) the spacing between rows is usually increased to at least 1.25 m. The spacing used between seed tubers in the furrow (row), depends on the size of the tubers. Small seed or "chats" are usually spaced 20 cm apart, while medium-sized seed (80-100 g) may be spaced 30 cm apart.		
FERTILIZATION	Potatoes have a poor root system, thus fertilizer should be applied at the same level, or just below the seed tubers. Plant the seed slightly on the side of the furrow with fertilizer or cover the fertilizer with a thin layer of soil. A general fertilizer recommendation for potato is 100g/m^2 2:3:4 (30) before planting followed by a side dressing of 200g/m^2 LAN at four weeks. Apply top dressing on both sides of the plant just before ridging, then ridge and irrigate. Water properly after application of the side dressing.		
IRRIGATION	Soil around seed should be moist and not too wet (to prevent rotting). Apply light applications (7–10 mm at a time). If temperatures are high, it is important to cool the soil with light irrigations. Adequate water supply is very important. Too long irrigation intervals may lead to tuber disorders. If the soil is too wet it can lead to attack by diseases. Less water is needed as the plants starts dying. Wet soil may lead to quality defects.		
HARVESTING	Potatoes can be harvested as soon as the tubers have matured sufficiently to resist mechanical damage. In most cases the skin of the tubers will be properly set (or matured) about two weeks after the foliage have died off. Readiness to harvest may be checked by digging out some plants and rubbing the tubers with your fingers. If the skin rubs off, the tubers should be left in the soil for another 7-10 days. The soil must be slightly moist when the potatoes are harvested.		
PESTS	More than 60 pests are known to attack potatoes in South Africa. *Consult "Guide to Potato Pests and their natural enemies in South Africa. D. Visser, 2005, ARC-Roodeplaat" for more information.* Potato tuber moth, potato leafminer and aphids are the three most serious pests of potato. Control: Several insecticides are registered for use on potato. Ridging		

	potatoes and ensuring that all cracks are covered will reduce damage of potato tuber moth larvae. Use seed that are not infected with insects. Do not discard old potatoes on nearby dumping sites. Remove volunteer plants from harvested fields. Nematodes. Control: The only two control actions that are affective against nematodes are nematicides (applied at planting time) and crop rotation.
DISEASES	Common scab, Control: Soil treatments (e.g. quintozene) and tuber treatments with chemicals. Plant resistant cultivars. Use scab free tubers for planting. Crop rotation (a 4 year cycle). Green manuring with Brassica crops. Bacterial wilt, early blight, late blight. Control: Plant certified seed. Do not cut seed tubers. Practice crop rotation. Don't harvest in wet conditions and limit damage to tubers. Spray with registered fungicides for blight. There are late blight resistant cultivars. Destroy potato plant rest after harvest. PVY^{NTN} (Potato virus Y^{NTN}) Control: Avoid planting any solanaceous crops close to potato fields to prevent transfer of the virus to potato by aphids. Regularly scout fields and remove infected plants. Regular sprays of registered aphicides may assist to control aphid populations and prevent spreading of the virus. Proper weeding.



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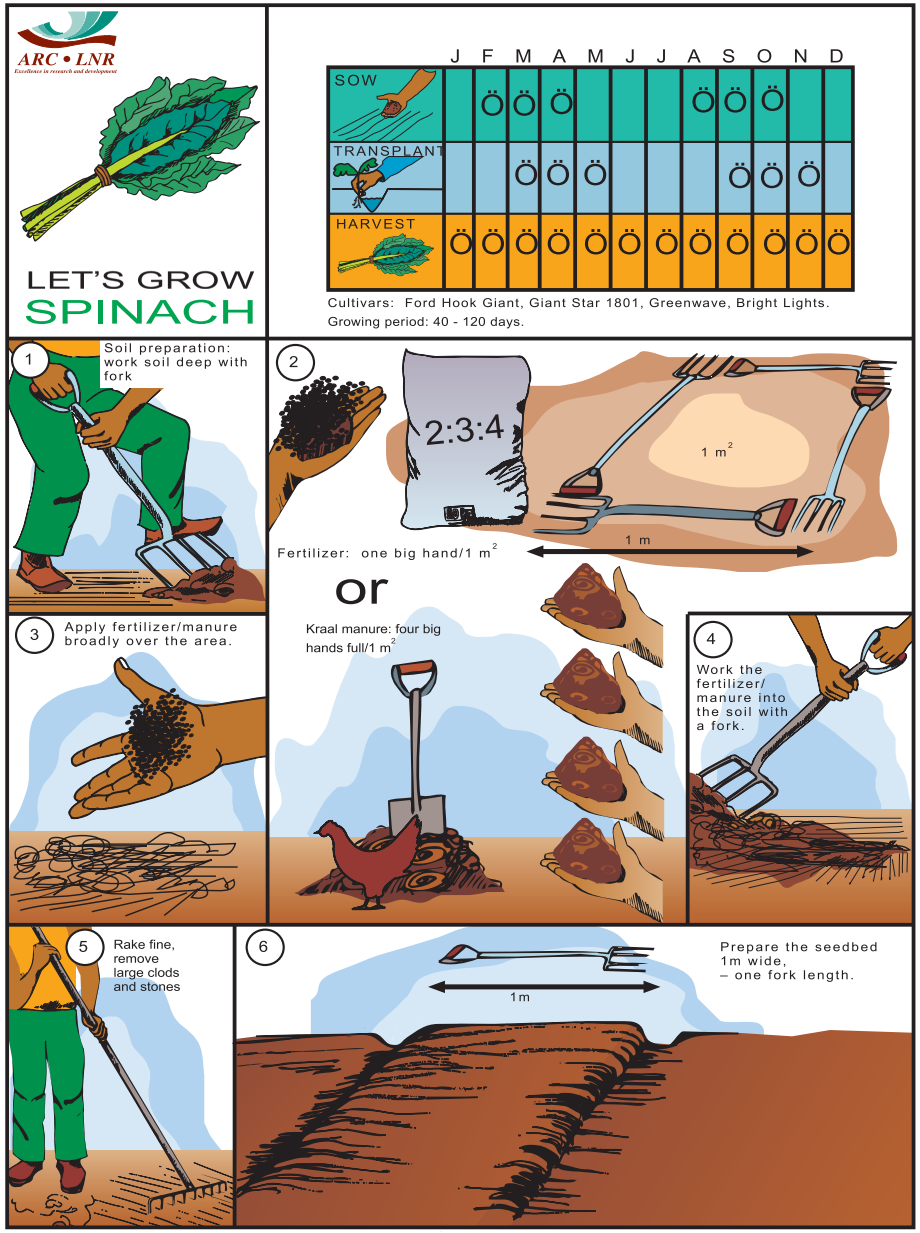
SPINACH (Swiss chard)

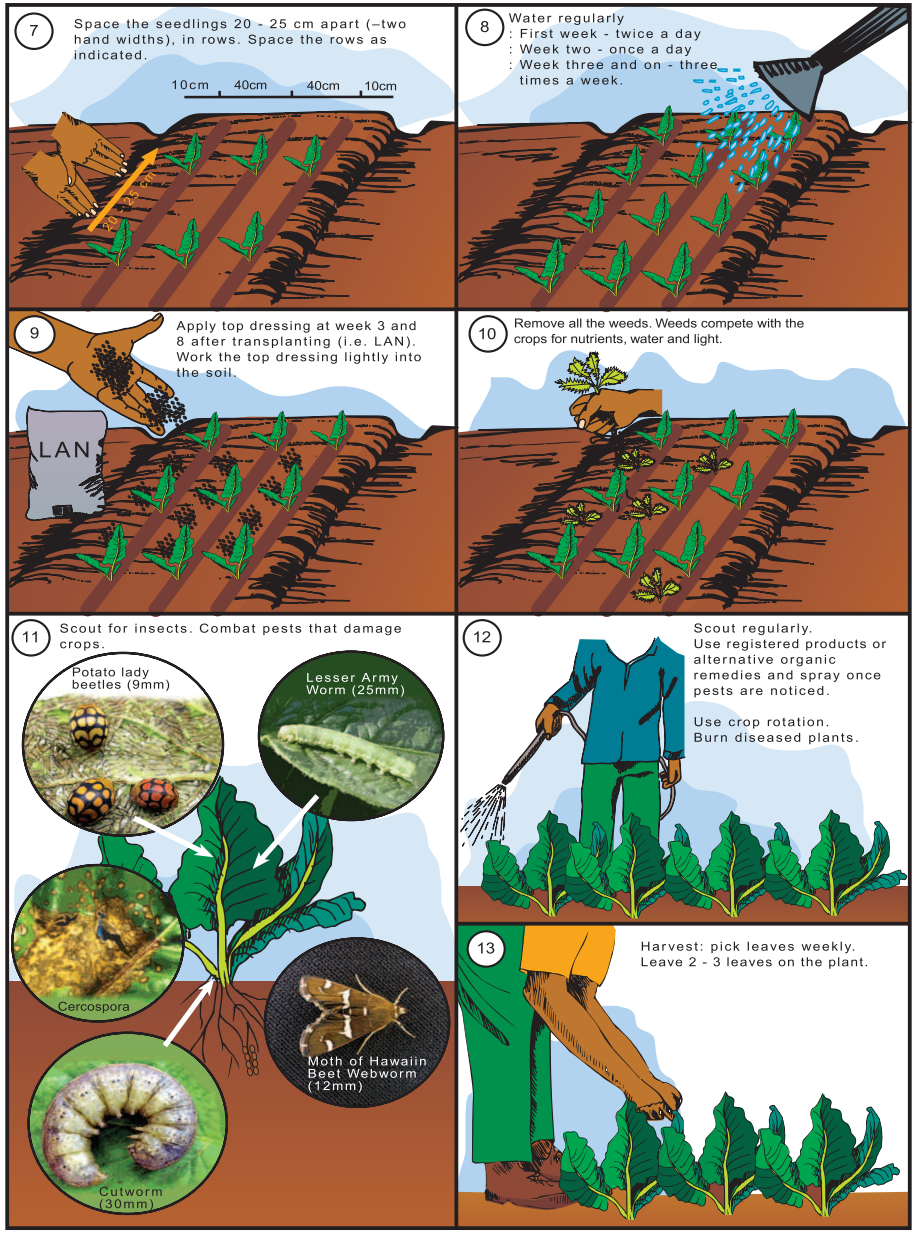
Swiss chard (*Beta vulgaris var. cicla)* belongs to the same family as beetroot and has become widely cultivated. It contains high levels of beta-carotene (provitamin A), folate, vitamin A and considerable amounts of readily available minerals (in particular iron). Uptake of iron by humans is enhanced by adding tomato (vitamin C) during cooking. The crop is relatively easy to cultivate and can be harvested regularly.

Local names:
Sesotho: Sepinitshe **Sepedi:** Sepinatshe **Setswana:** Sepinatshi **IsiNdebele:** Isipinatji **isiXhosa**: Isipinithji
Tshivenda: Tshipinatshi **isiZulu:** Isipinashi **siSwati:** Spinach **Xitsonga:** Sepinache

SOIL	Spinach requires fertile, well-drained soil. A sandy loam soil is the best but it also does well in a loam to clay soil with a pH (H_20) of 6.0 to 6.8.
CLIMATIC	It is a cool weather crop, but can also be grown in hot summer months. However this can results in bolting in some cultivars. Optimum temperatures range between 16 and 24^{o}C. The best time to plant is from mid February to April and from August to October.
CULTIVARS	Ford Hook Giant (FHG) Giant Star 1801 Greenwave Bright Lights
CROP ROTATION	Rotate the crop with other vegetables such as pumpkin, beans, peas, lettuce, tomatoes, potatoes and cabbage.
SOIL PREPARATION	Cover crops (green manure) can be planted and worked into the soil 4-6 weeks before establishing the crop. The soil must be watered properly before preparation. Loosen the soil properly with a plough or fork. For direct sowing, the seedbed must be very fine in structure. Big clods will prevent germination.
PLANTING METHOD AND SPACING	Seedlings can be planted in rows with spacing of 20-25 cm between plants and 25-35 cm between rows. Seeds can also be sown directly in shallow rows or furrows. Use a spade or rake to make the furrows more or less 2-3cm deep. Sow seeds 3 cm apart and cover with soil using a spade or rake. The soil must be watered directly after sowing and properly covered with a

	thin layer of grass (mulching) in hot seasons. The soil must be kept damp until the plants have germinated, 7-8 days. Remove the grass after 5-6 days to prevent long leggy seedlings. Thin out to 15-25 cm between plants by 3 weeks after emergence.
FERTILIZATION	General recommendations: Approximately 100g/m^2 of a fertilizer mixture such as 2:3:4 (27) must be applied before planting and mixed into the top 10 cm of the soil. Spinach reacts well on compost or manure (4 hands of manure/m^2). This may be used to supplement a part of the chemical fertilizer. Apply top dressing at 3 and 8 weeks after transplanting or emergence at a rate of 10 g of KAN/LAN per meter row. Apply in the area 5-15 cm away from the plants at both sides.
IRRIGATION	Spinach has a very shallow root system; therefore the soil must be kept moist throughout the active growing season of the crop. Two light irrigations are better than one heavy irrigation period because of the shallow root system.
HARVESTING	Harvesting starts 1-2 months after transplanting. The crop must be harvested regularly to stimulate re-growth, higher yield and reduce bolting (making seed stalks). Only the outer leaves must be removed with a sharp knife, 30-50 mm above the soil. Be careful not to damage the new buds.
PESTS	Cutworms, red spider mite, Hawaiian beet webworm, lesser armyworm, potato lady beetle, nematodes. Control: Scout regularly. Use cutworm bait. Use registered pesticides.
DISEASES	Cercospora leaf spot Control: Practice crop rotation and treat the seed with a registered chemical. Pythium Root Rot Control: Avoid over-irrigation. Plant in well drained soils. Treat the seed with thiram. Practice crop rotation. Make sure that the crop does not lack sufficient boron. Plant at the right time and not too deep.





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SWEET POTATO

Sweet potato (*Ipomoea batatas*) is not related to the common potato. Sweet potato belongs to the morning glory family and produces edible storage roots. Sweet potato is an important food and poverty relief crop that can be used to combat the widespread deficiency of Vitamin A. Orange-fleshed cultivars are rich in beta-carotene and thus used in food-based programs to address vitamin A deficiency. Sweet potatoes are rich sources of energy but also contributes vitamin C and minerals such as magnesium, copper, iron and zinc. The white-fleshed and the orange-fleshed are the two common types in South Africa.

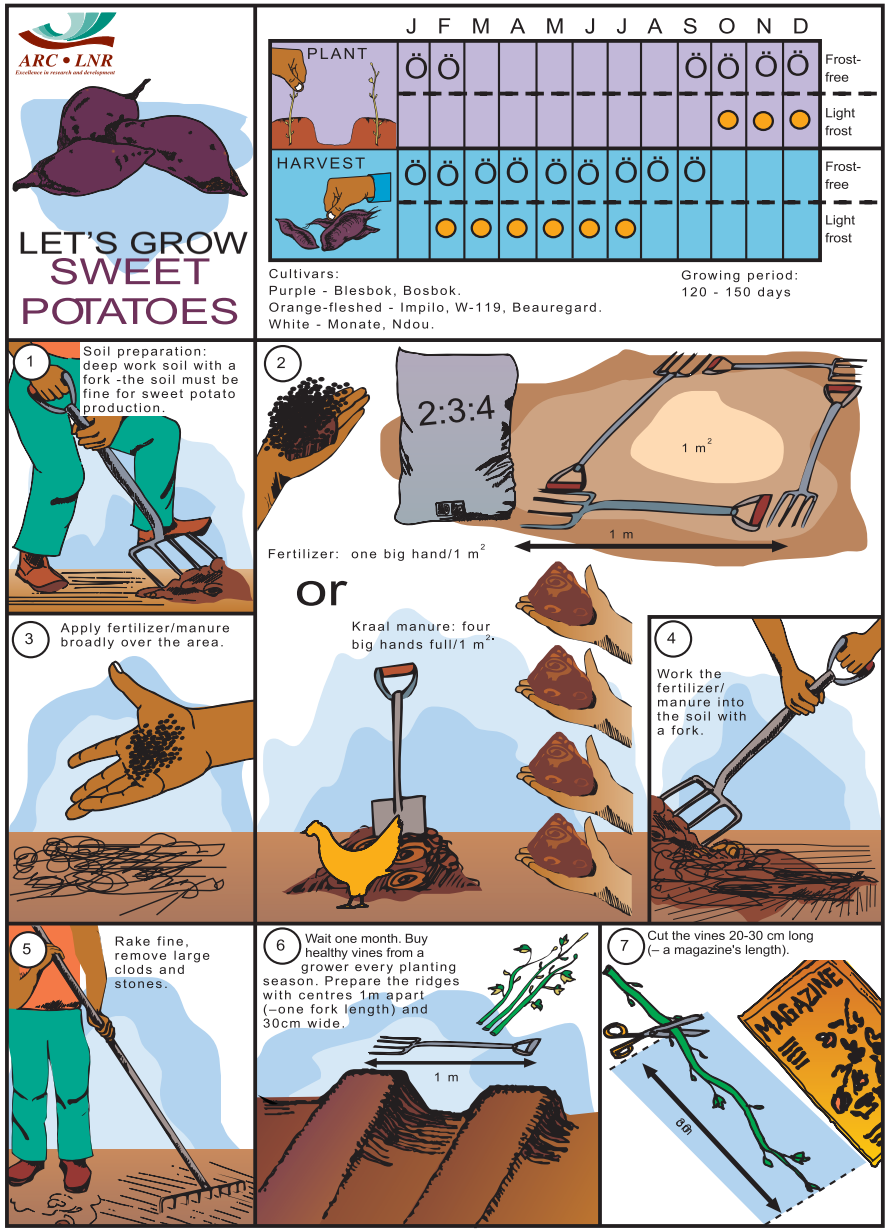
For detailed information consult: Niederwieser, J.G. 2004. Guide to sweet potato production in South Africa. ARC-Roodeplaat.

Local names:
Sesotho: Potata **Sepedi:** Potata **Setswana:** Potata **IsiNdebele:** Ibhutata
isiXhosa: Ibhatata **Tshivenda:** Switi potata **isiZulu:** Ubhatata **Swati:** Bhatata
Xitsonga: Nhlata yobhasa

SOIL	Sweet potatoes grow well in sandy-loam, loam or clayey-loam soil. The crop needs good drainage and is sensitive to water logging, salinity and alkalinity. Optimum pH (H_20) is 5.6 – 6.5. Avoid stony or clay soil.
CLIMATE	Sweet potato is a warm season crop. Sweet potatoes are sensitive to low temperatures, especially frost.
CULTIVARS	Orange-fleshed: Impilo and W-119 (dry); Beauregard (moist) Purple skin (fresh market): Blesbok, Bosbok (moist) Cream skin: Ndou, Monate (dry)
CROP ROTATION	Sweet potatoes should not be grown more than once every 3 years on the same soil. Suitable soil restorative crops such as peas, cabbage, beans and maize should be included in the rotation system.
PROPAGATION	Propagation is by stem cuttings. Healthy, insect and disease free pieces of stem of 20-30 cm long should be taken for cuttings. Top cuttings are more vigorous. Do not use vines from volunteer sweet potatoes. Cuttings may be obtained from storage roots: Plant sweet potatoes horizontally two-thirds into the soil. When sprouts are 25-30 cm long, break them off and use for planting.
SOIL PREPARATION	Loosen the soil to a depth of 250-300 mm to ensure good root aeration, root penetration and drainage. Remove stones and break hard layers to ensure good root penetration. Cover crops (green manure) can be planted and worked into the soil 3-4 months before establishing the crop.

PLANTING METHOD	**Ridging:** The plants are grown on ridges or mounds. These are especially beneficial in areas liable to flooding and also to ease harvesting. Cuttings are laid 30 cm apart on the ridge with the basal end planted in the soil (3 - 4 buds (nodes) in the soil) and the soil pressed down firmly around the cutting. **Flat bed:** Some farmers grow sweet potatoes on flat beds in sandy soil with good results.
SPACING	Place stem cuttings 25-35 cm apart within the row. Generally ridges of 1 m apart are used. But it can be 90-150 cm apart for field production or 80-90cm for gardens, and ridges about 30-40 cm 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. In cooler areas September to February. Winter rainfall areas: mid November to beginning of December; November is optimal.
FERTILIZATION	General recommendations: Approximately 100 g/m^2 of a fertilizer mixture such as 2:3:4 (30), or 3:2:1 (25) can be broadcasted directly before planting and must be worked into the soil slightly before making the ridges. For sandy soils the amount can be increased to 120 g/m^2. Apply a top dressing of 12 g LAN per meter of row or 20 g/m ammonium sulphate at 3 weeks after planting, and again 6 weeks after planting if necessary. Sandy soil will require at least two top dressings. Water well after application of fertilizer. If compost is applied, it must be well-matured (6 months old), or be worked into the soil some time before planting. Four 4 big hands/m^2 can be broadcast and incorporated before planting.
IRRIGATION	Sweet potato is moderately drought tolerant. However, lack of water will reduce the yield. Water stress during the first few weeks after planting and the period of storage root formation (30-60 days after planting) will cause low yields. As a general guide, sweet potato requires between 450 and 600 mm of water well distributed throughout the growing season.
HARVESTING	Usually 4 months (warm areas) to 5 months (moderate areas) after planting. Soil should be soft during harvest to prevent breakage and skin damage. Withhold watering from around 30 days prior to harvesting as a way of field curing. In warm areas cut vines 4-7 days before harvesting to cure. Use a hand-fork to lift up the storage roots and then take out by hand. Make sure not to damage storage roots in any way during harvesting.
PESTS	Sweet Potato Weevils Control: Crop rotation. Ridging of the storage roots and preventing soil cracking. Burn all infested plants after harvesting Use insect-free cuttings. Do not plant cuttings close to the previous sweet potato crop. Remove all storage roots at harvesting and never use cuttings from volunteers.

	Sweet Potato Hawk Moth larvae Control: Hand picking of larvae is usually sufficient if numbers are not high.
DISEASES	Fusarium wilt, Alternaria leaf spot. Control: Plant tolerant varieties. Use disease-free planting material. Rotate crop with non-hosts. Limit any stress such as water deficiency and high temperatures during the growth season to avoid Fusarium wilt. Sweet potato feathery mottle virus. Control: Plant virus-free planting material. Control weeds in and around the field, especially wild *Ipomoea* species. Remove volunteer sweet potato plants, debris and weeds from the previous season before planting. Clean all cutting equipment with a strong solution of Jik.



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TOMATO

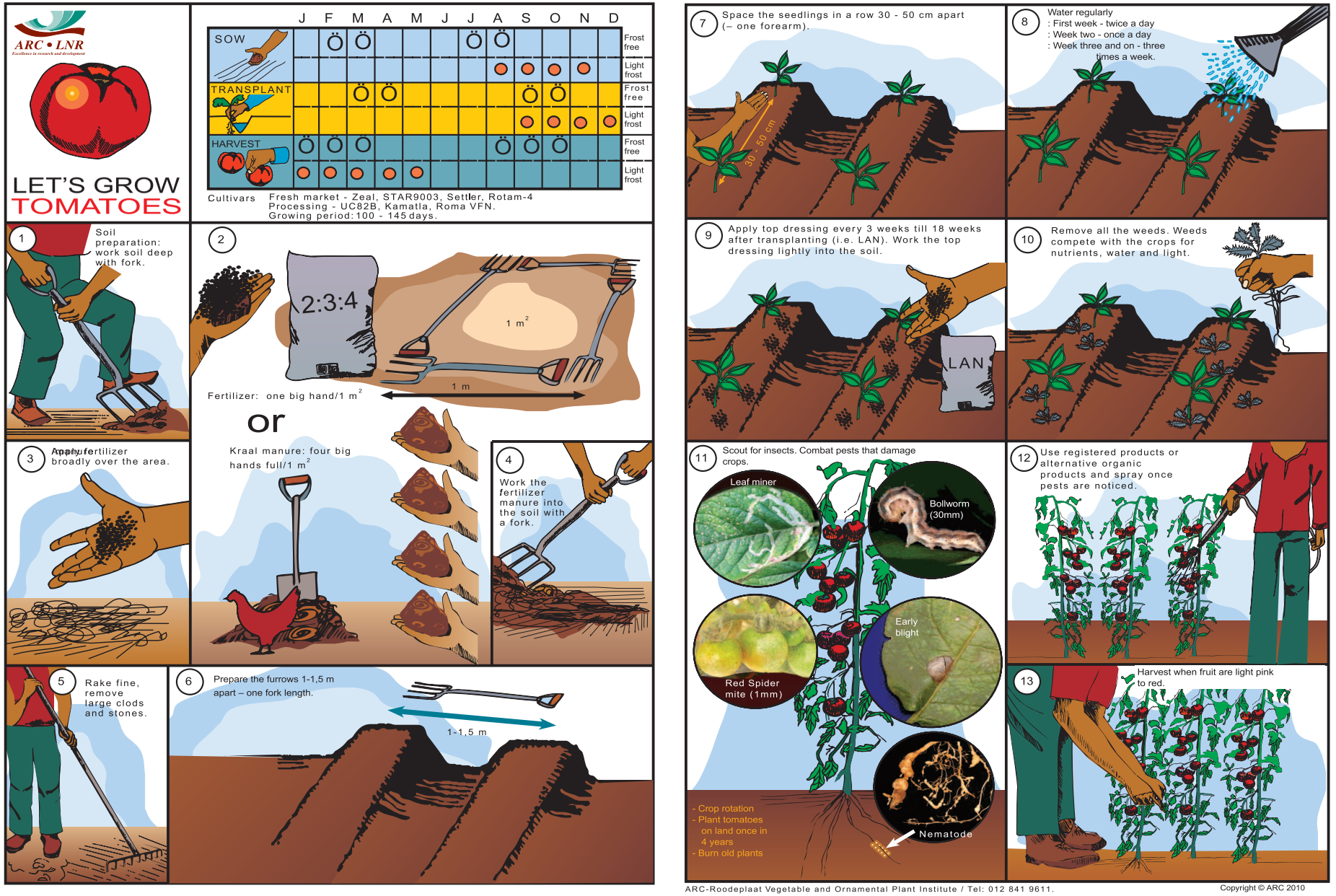
The tomato (*Lycopersicon lycopersicum*) is one of the most popular vegetables cultivated in all parts of the world. Throughout the world there are several hundred of cultivars and strains of tomatoes and in recent years much research has been done in breeding new cultivars and hybrids for specific purposes. The crop is generally susceptible to a variety of pests and diseases.
Tomato is a good source of vitamin C as well as minerals. In South Africa tomato is the second largest vegetable produced after potato.
Tomato belongs to the Solanaceae family. Other crops in the family are eggplant and pepper

Local names:Tomato
Sesotho: Tamati **Sepedi:**Tamatisi **Setswana:**Tamati **IsiNdebele:** Itamati **isiXhosa**: Itamatu
Tshivenda: Tamatisi **isiZulu:** Utamati **Swati:** Litamatisi **Xitsonga:** Tamatisi

SOIL	Tomato can be grown in different types of soil but the soil should be well drained and provided with organic matter. A deep loam soil is the best. A soil pH (H_20) spectrum of 5.6 - 6.8 is recommended.
CLIMATIC	Tomato can grow in a wide range of temperatures, but for optimum growth it prefers temperatures between 10 and 30^0 C. It is a warm weather crop and sensitive to frost. The best results are obtained under dry and cloudless weather.
CULTIVARS	**Fresh market** Zeal, Score, Checha, STAR9003, Disco, Bravo, Stormer, Settler, Sundance, Rodade, Flora-Dade, Rotam-4. **Processing** UC82B, Kamatla, Qwanto, Roma VFN. There are more cultivars available from different seed companies in South Africa. Cultivars should be selected according to fruit type, plant habits, disease resistance, adaptation to season and hybrid or open pollinated.
ROTATION GROUP	Rotate tomato with cabbage, spinach, beans, peas and non-related crops. Do not rotate with potato, sweet pepper, chilly, egg fruit and Cape gooseberry and other members of the Solanaceae family.
SOWING METHODS	Prepare a fine seedbed. Sow seed in a nursery and transplant approximately 5 weeks later. For 1 ha, 500 to 750 g of seed is required. The seed is sown in furrows and covered with a layer of soil about 20 mm deep. Else seed can be sown in seedling trays, egg holders or small pots. After sowing, cover the seeds with light soil and compact the soil firmly with your hand. Put dry grass on the top of the bed to prevent drying of the soil. Water once a day. Take the grass off just after germination after about 7 to 8 days.

SPACING	In-row spacing ranges from 30 – 50 cm and 1.0 – 1.5 m between the rows.
PLANTING TIMES	Guidelines: • Gauteng, western part of Mpumalanga and Free State highveld (October – November) • Limpopo, North West and northern Mpumalanga middelveld (September – December) • Limpopo and Mpumalanga lowveld e.g. Malelane, Hoedspruit, Messina (February – March and July – August) • Southern Free State, western part of North West, Northern Cape and northern part of Western Cape (September – November) • KwaZulu Natal – Midlands (August – November) • Eastern Cape (August – October) • Southern part of Western Cape (July – September)
TRANSPLANTING	Water the bed properly a day before transplanting. Remove the seedlings from the seed beds with soil on the roots with a small spade or iron bar. Make holes and transplant the seedlings in the holes. Plant the seedlings a little bit deeper than in the nursery. Water the plants immediately. Transplant during morning hours (preferably during cloudy days) or late in the afternoon. Transplant only healthy seedlings.
FERTILIZATION	Adequate supply of potassium is important for fruit solidity. General guideline: Prior to planting apply 100 g/m^2 of a fertilizer mixture such as 2:3:4 (30) + Zn Or use organic fertilizers e.g. compost of manure (4 hands of manure/m^2). Cover crops (green manure) can be planted and worked into the soil 4-6 weeks before establishing the crop. Tomato plants will respond well to a top or side-dressing of 5 g/m^2 1:0:1(39) and 5g/m^2 LAN (28) alternated, every 3 weeks after transplanting until week 18 as long as plants are still growing and healthy.
IRRIGATION	Sufficient water at critical times e.g. immediately after sowing or transplanting are important. During the first four weeks 21 mm/week is needed, the following eight weeks 38 mm/week and during the remainder of the growing season 31 mm/week. Too much water after the fruits have formed can cause cracking. Approximately 500 mm is required throughout the growing season.
HARVESTING	Tomatoes take 110 - 130 days to mature after transplanting. Harvest when the fruits are light pink to light red.
PESTS	Cutworm Control: Cultivate on a land free of weeds. Weed control must start 6 weeks before sowing or transplanting. Use cutworm bait. African bollworm, leafminers (*Liriomyza*), red spider mites, tomato rust mite, caterpillars, potato tuber moth green vegetable bug. Control: Use registered pesticides. When numbers are low, caterpillars and bollworm

	can be removed by hand. Root knot nematodes Control: Plant tolerant cultivars and rotate with e.g. marigolds. Several nematicides are registered for nematode control on tomatoes. Avoid nematode infected fields. Practice fallow ploughing.
DISEASES	Bacterial canker, bacterial wilt, bacterial speck/black stem, early blight, late blight, powdery mildew, gray mould Control: Plant disease-free seedlings. Apply strict sanitation in and around plantings. Implement crop rotation. Plant resistant cultivars. Avoid over-irrigation and overhead irrigation. Use clean irrigation water. Apply chemical control. Eradicate weeds and volunteer tomato plants. Tomato Spotted Wilt Virus (TSWV), Potato virus Y (*PVY*), tobacco mosaic virus (*TMV),* tomato yellow leaf curl virus (TYLCV). Control: Use disease-free seeds/seedlings. Destroy diseased plants. Control whiteflies, thrips and aphids with pesticides. Control weeds within and around the crop. Apply strict sanitation. Use resistant varieties. Ban the use of tobacco products in and around the planted area (TMV). Blossom end rot (Hard brown area on blossom end). Control: Mulching. Avoid root pruning. Regular irrigation. Apply calcium (calcium nitrate, gypsum and lime). Avoid high nitrogen fertilization.
CROP MANAGEMENT	Staking/trellising prevents fruits from touching the ground and thus limits the occurrence of diseases on the fruits or leaves.



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VEGETABLE AMARANTH

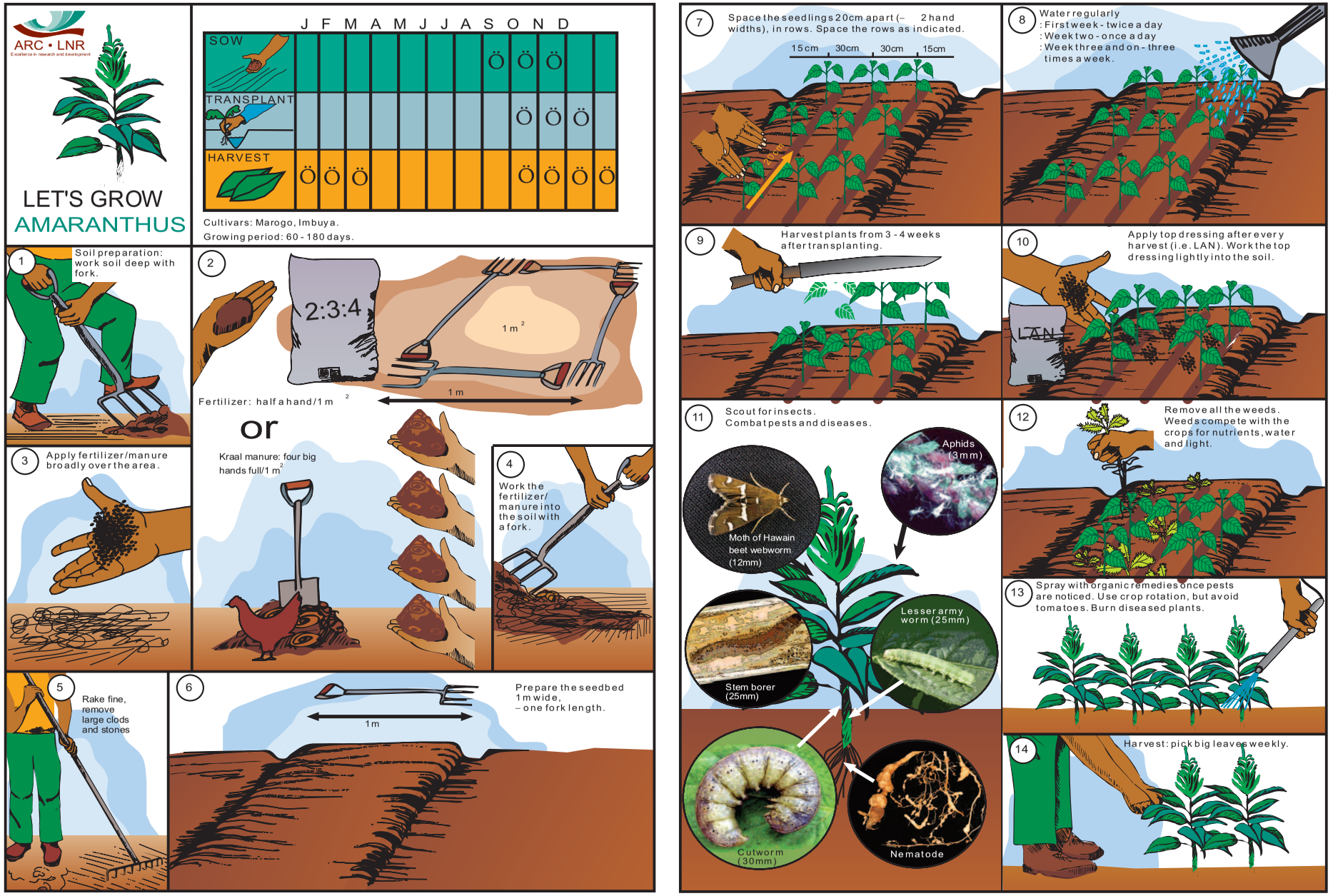
Amaranth (*Amaranthus spp*) originated in the Andean region of Central and South America or Mexico. The leaves and young stems are eaten as a vegetable. There is a large potential for this rapidly maturing crop to fit into multiple cropping systems (rotation systems). Vegetable amaranth contains a significant amount of usable protein and also is rich in minerals (e.g. iron) and vitamins (e.g. vitamins A and C). Species suitable for production include *Amaranthus hypochondriacus, A. tricolor, A. cruentus, A. hybridus*

Local names:
Sesotho: Thepe **Sepedi**: Thepe **Setswana:** Thepe **IsiNdebele:** Imbuya **isiXhosa:** Unomdlomboyi
Tshivenda: Vowa **isiZulu**: Imbuya **Swati:** Imbuya **Xitsonga:** Theyke/cheke

SOIL	Well drained soils with a high organic content and adequate nutrients, are necessary for optimal growth. Soil with a loamy or sandy-loamy texture with a pH between 5.5 and 7.5 is considered optimal.
CLIMATE	Amaranth is a warm weather crop and is sensitive to frost. Sowing at low soil temperatures (below 15 ^{0}C) can lead to poor germination.
CULTIVARS	In South Africa there is no leafy amaranth cultivar commercially available. Kirchhoffs are distributing marogo/imbuya seed.
CROP ROTATION	Rotate with other crops because it usually leaves the field with relatively few weeds. Include other crops like winter cereals, legumes, cabbage or carrots. Amaranth also suppresses nematodes. Intercrop with nightshade, cleome, tomatoes, potatoes, corchorus and kale, but not maize.
PLANTING TIME PER REGION	x The Highveld, Free State, Northern Cape (severe frost in winter): October to November x KwaZulu-Natal Midlands, Middleveld, Eastern Cape (light frost in winter): September to December x The Lowveld (no frost in winter): March-April and August x Western Cape (Winter rainfall region): October to December
PROPAGATION	Amaranth is grown by sowing seed directly or sowing the seeds into beds or seeding trays and then transplanted. Amaranth could be sown/broadcasted directly and then thinned out to achieve the desirable spacing.
SOIL	Take out weeds and loosen soil deeply with a fork, then apply fertilizer or

PREPARATION	compost/manure. Prepare a fine seedbed. A raised seedbed ensures good drainage and thus better disease control.
PLANTING DEPTH	Due to small seed size shallow planting is required. Most seed emerges at a sowing depth of 1 – 13 mm. Less seed will emerge if the seed is sown deeper.
SEED RATE	Seed is broadcasted at a rate of 3 - 10 g per square meter. Mix the seed with fine, dry sand in the ratio of 1:20 to ensure uniform distribution. Cover freshly sown seeds with mulch or grass or straw to protect them from adverse climate conditions. Remove the mulch after germination. Thin out seedlings 3 weeks after germination before reaching a height of 10 cm.
SPACING	Spacing will be determined by the method of planting: • Planting in rows: 8 – 15 cm between plants; 20 – 30 cm between rows • Broadcast sown seedlings: 20 cm x 20 cm between plants after thinning
FERTILIZATION	General guidelines: • On acid soils (pH < 5.0), apply lime at least 4 weeks before planting. • Any green manure crop should be ploughed in at least 3-4 months before planting. • Pre-plant: 30 g/m^2 2:3:4 (30) + 0,5% zinc broadcasted and incorporated prior to planting. Top dressing: 8 g/m^2 N after each harvest. • Well-ripened manure at a rate of 2 - 3 kg/m^2 at least 2 months before planting.
IRRIGATION	Amaranth is an important dry land crop for vegetable production in semi-arid regions because it has a relatively low water requirement. Good yields can be obtained with a rainfall of 200 mm evenly distributed in the growing period. Sow seed in moist soil and irrigate daily after sowing to ensure good germination and emergence. Wet the soil after transplanting and then every 2 to 4 days.
HARVESTING	Harvesting (picking) can commence 21 days after transplanting for up to 180 days. Basically two methods can be used: **Uprooting** It referes to pulling the whole plant during thinning amaranth that was sown directly. The first uprooting can take place as soon as a week or two after germination. Harvesting continues weekly or fortnightly until the desired spacing is reached. After 6 weeks, all remaining plants can either be uprooted or harvesting can take place by repeated picking of the shoots. **Ratoon cropping** Partially matured plants are harvested in succession. First the main shoots are cut 20 cm from the ground when the plants reach a height of 20cm. This stimulates the development of strong lateral shoots. Subsequent harvests involve the cutting of the side shoots.
PESTS	Hawaiian beet webworm, cut worms, aphids, sucking bugs, thrips, weevils, the lesser army worm, stem borers and root-knot nematodes

	Control: Crop rotation is an important strategy to help combat pests. Practice weed control effectively as many weeds can host pests.
DISEASES	Not much is known about the control of diseases in vegetable amaranth. In general amaranth is regarded as reasonably resistant. Seedling damping off, stem canker, *Alternaria* leaf spot, Powdery mildew are some of the few. Control: Use high quality seeds. Ensure well-drained soils and ensure optimal plant density. Practice weed control effectively as many weeds host diseases, keep fields free from weedy amaranth, use well-decomposed organic manure, practice crop rotation. Note: There are no chemicals registered for control of pest and diseases on amaranth.



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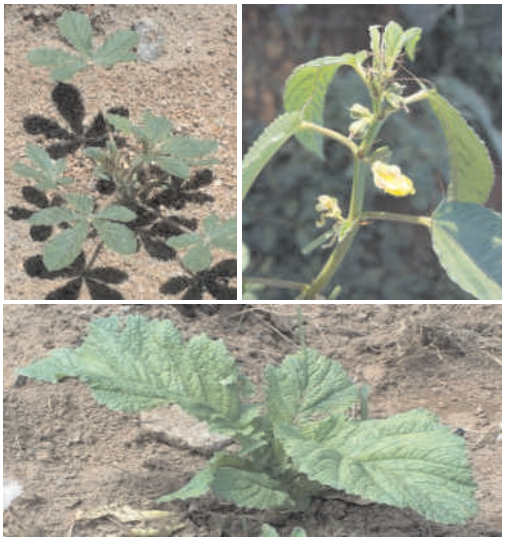
OTHER AFRICAN LEAFY VEGETABLES

Marogo or imfino (African Leafy Vegetables – ALV's) are well known to thousands of South Africans. It is harvested in the veld and with "styfpap" (stiff porridge) it forms the staple diet of many households. These leafy vegetables can be grown for easy harvesting. 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).

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



Local names:
Sesotho: Meroho **Sepedi**: Merogo **Setswana:** Merogo e metala **IsiNdebele:** Umrorho **isiXhosa:** Imifino
Tshivenda : Tshikoli **isiZulu:** Imfino **Swati:** Umbhidvo **Xitsonga:** Murhoho

SOIL	Sandy, sandy loam and loam soils is preferable but ALV's will grow in almost all soil types. Kale does not grow well when roots are kept wet.
CLIMATE	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	Most of the African leafy vegetables could be intercropped with each other or with maize. For instance, spider flower could be a companion crop for nightshade and amaranths. The fast growing spider plants are harvested before the other two.
SOWING METHOD	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. Thin plants out or transplant when seedlings are 15 cm tall, or sow direct and thin out at 5 weeks. Seed could also be broadcasted in fine seedbeds. . Start weeding when the seedlings are established and continue at least until the leaves cover the ground or until the end of the season.

SPACING	Small crops: 10 - 15 cm between plants Large crops: 20 - 30 cm between plants 30 - 50 cm between rows
FERTILIZATION	Apply well ripened manure at 2 - 3 kg/m^2 before planting. Use a quarter of the above amount if using chicken manure. High levels of nitrogen manure will delay flowering and increase the leaf yield. 100 g/m^2 of ash can be added for *Corchorus*.
IRRIGATION	Plants require water 2 or 3 times a week. Drought will hasten development of flowers and lower the yield.
HARVEST	Harvesting can be done by uprooting, cutting back or picking the leaves. Once plants are growing well, frequent harvesting of leaves or shoots can take place. The growing period can be up to 150 days.
PEST & DISEASES	Pests and diseases are seldom a problem. However the following need to be managed: Flea beetle, nematodes, stem borer, pod borers and cutworms aphids, Diamond back moth, Mosaic virus. Control: Apply strict sanitation measures during the growing season. Monitor / scout crops for important pests and diseases. Use registered chemicals to control virus vectors.
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, add ash and charcoal to the containers to keep the insects away. Store the containers in a cool, dry and dark place.

GARLIC

Garlic (*Allium sativum*) belongs to the same family as onions, namely Alliaceae. The bulb formation of garlic is regulated by day length, and the cultivars are adapted to different regions based on latitude. The plant is used as a culinary herb, a salt or as a cure for several ailments such as high blood pressure and as an anti inflammatory product. Garlic is a hardy perennial, but it is often cultivated as an annual. Bulbs consist of cloves, or bulblets in a papery white or pinkish white casing.

For a complete guide on garlic contact ARC-Roodeplaat, Pretoria: Guide to garlic production in South Africa – JG Niederwieser, 2004.

SOIL	Garlic requires well drained and fertile soil. The pH must be between 6.0 and 8.0. Avoid soils that tend to form a hard crust because growth and bulb development can be impaired.
CLIMATIC	Garlic is a cool weather crop and tolerate frost conditions The optimum temperatures between 13 - 24ºC. Longer days and increasing temperatures during spring enhance growth and bulb development.
CULTIVARS	Elephant garlic (common garlic) and Egyptian White. Make sure to grow an adapted cultivar for your area.
PLANTING TIME	Summer rainfall areas: February – March for common garlic and mid March to mid April for elephant garlic. Planting in cool areas is done earlier than in warm areas, to ensure stronger plants before frost appears.
PROPAGATION	Cloves are used as planting material. Sprouting occurs 10 - 20 days after planting.
PLANTING METHOD	A spacing of 35 – 45 cm between the rows and 6 – 7 cm in the rows is a good option for garlic. Generally, narrow spacing results in high yields of smaller bulbs but wide spacing lowers yields and larger bulbs are obtained.
FERTILIZATION	General fertilizer recommendation: 90 -120 g/m^2 of 2:3:2: (22) + Zn on fairly poor or new soils. Two top dressings should be applied 3-5 weeks after emergence if necessary at 10 - 15 g/m^2.

	Care should be taken that the top dressings should not be applied late in the season because thick necks and bushy plants can result.
IRRIGATION	Keep the top layer of the soil moist at all times until plants have been established. The most critical stage for irrigation is during bulb formation. Irrigation should be stopped 2 - 3 weeks before harvest.
HARVESTING	Signs of readiness for harvest: - Plants change colour at the end of the season. - Leaf tips start to dry out, especially the youngest leaves. - Plant necks become soft. - Plants start to fall over. - Cloves fill the skins and do not shrink within 24 hours after cutting. Bulbs should be dried after harvesting to prevent post harvest rotting. The simplest way to dry bulbs is in the field in wind rows, or stacks for at least 5 days. Clean the bulbs after drying and cut off the roots and leaves.
PESTS	Bulb mites, thrips, aphids, nematodes Control: Practice crop rotation. Use registered chemicals.
DISEASES	Blue mould, pinkroot, downy mildew, purple blotch, white rot, rust. Control: Plant healthy cloves, practice crop rotation, plant in well–drained soils, avoid dense population of plants. Infected crop debris should be removed or ploughed in deeply after harvest to reduce pathogen levels in the soil. Chemicals are available to control white rot, blue mold and purple blotch. Fallowing will also reduce pink rot.
MEDICINAL USES	Garlic helps to lower blood pressure and blood cholesterol. Helps prevent blood clotting. Acts as a decongestant. Antiviral and antibacterial properties.

BASIL

Ocimum basilicum of the family Lamiaceae (mints), is a tender low-growing herb. Basil is a culinary herb and often used in Italian and Thai dishes.

DESCRIPTION	Basil is a multi-branched semi-hardy annual herb. The mature plant is about 50 cm tall with soft, ovate, bright green leaves. Whorls of small white flowers are borne in terminal racemes in mid to late summer. The different species may differ considerably in pungency and flavor. This is somehow influenced by soil, climate and growing conditions. Basil hybridizes easily and many seeds sold commercially are not recognized as distinct varieties or cultivars.
CLIMATE	Basil is tender and should be sown in seed trays under glass in late spring to early summer.
SOIL	Basil requires well-drained, moist, medium rich soil in full sun.
PROPAGATION	Basil is propagated from seeds, which must be sown after the frost in cool regions. It normally flourishes as a container plant and should be kept outside in hot, dry conditions to develop best flavour.
PLANTING METHOD	*Spring:* Sow seeds in early spring. Transplant towards the end of spring. *Summer:* Keep pinching out young growth tips to stimulate new growth and prevent the plant from flowering. *Autumn:* allow plants to set seed and collect seeds. Before the frost begins plants should be removed. Land can then be prepared for new plants.
FERTILIZATION	Comfrey tea can be used to fertilize all types of herbs. Liquid fertilizer: fill a bucket halfway with comfrey leaves, fill it with water and cover with a lid (to exclude insects). Leave for 4-5 weeks and then strain the liquid. This will have a strong smell. Dilute and use as organic fertilizer.
HARVESTING	Pick leaves at a young stage, always from the top to encourage new growth. If freezing paint sides with olive oil to stop from sticking. Dry basil as soon as possible. Most successful processing is to infuse the leaves in olive oil or vinegar.

PESTS & DISEASES	Greenfly and whitefly on pot plants. Seedlings are very susceptible to damping off, a fungal disease encouraged by overcrowding in too wet conditions.
MEDICINAL USES	Fresh leaves may be rubbed on insect bites and stings to relieve itching. Make cough syrup with honey and taken as infusion for colds. Leaves or essential oils are used in steam inhalations as a decongestant for colds. Antidepressant, antiseptic, soothing properties. Diluted essential oils make an insect repellent or massage oil (for depression and anxiety). Can be used as a sedative against gastric spasms and as a laxative. It is also a good companion plant which repels insects.

ROSEMARY

Rosemary (*Rosmarinus officinalis)* is a woody, perennial herb having fragrant needle-like leaves. It also belongs to the mint family Lamiaceae. The name “rosemary” comes from the Latin meaning “dew of the sea”.

DESCRIPTION	Rosemary is a variable evergreen shrub, which can grow up to 2m. It has woody branches and strongly aromatic, needle-like foliage. A dense covering of small, tubular, two-lipped flowers, usually pale blue appear in spring. Some species are frost-hardy. It needs a sunny, sheltered position with protection in cold winters and during periods of prolonged frost.
SOIL	The plant is well adapted to well drained, stony soils and requires little moisture.
CLIMATE	Spring is normally the best time to sow rosemary seeds, but don’t start too early to prevent frost damage.
PLANTING METHOD	*Spring:* trim after flowering, sow seeds and make softwood cuttings *Summer:* take semi wood cuttings *Autumn:* protect young tender plants *Winter:* put mulch or straw around plants. Although rosemary is a perennial it is best to replace bushes every 5-6 years.
PROPAGATION	Rosemary is easily propagated from semi-ripe cuttings taken in summer. It becomes straggly unless pruned hard in summer. This should be done after flowering but plants should not be cut back to old wood.
HARVESTING	Rosemary is evergreen and can be picked fresh all year round. If you need large quantities, harvest during summer and either dry the leaves or make oil.
PESTS AND DISEASES	Rosemary beetle and its larvae feed on the leaves from autumn until spring.
OTHER USES	It is a restorative, tonic herb, with antiseptic and antibacterial properties. An infusion is taken against colds, influenza, fatigue and headaches. It is also a good mouthwash for halitosis and a good antiseptic gargle. Drinking small amounts reduces flatulence and stimulates smooth muscle movement of the digestive tract and gall bladder. Tinctures are used for depression and nervous tension and also applied externally in massage oil for rheumatic and muscular pain. **Not safe to use during pregnancy.** Essential oils are added to bath water for aching joints and tiredness. Boil a handful of leaves in 500ml of water for 10 minutes. It helps enhances blood circulation if rubbed into the affected joints. The oil may be used externally as an insect repellant.

6. AGRICULTURAL SYSTEMS FOR FRUIT CROPS

6.1 General considerations for growing fruit

Apart from producing fruits, trees are also useful for providing shade, preventing soil erosion and serving as wind breaks. Fruit trees require specific management practices, some of which are discussed below. Detailed practices for each fruit crop are provided in Part 7: Fact sheets on fruit trees. The establishment of a fruit garden is a long term investment. The success thereof largely depends on purchasing good quality plants and sound orchard/garden management practices. What to consider before establishing a fruit tree garden

- Determine which fruit can be grown based on the climatic conditions of your area.
- Choose crops and select the correct cultivar to be planted.
- Ensure that your soil and climate are suitable for optimum growth of the trees.
- Decide how the harvest will be used (school feeding or for sale) and the responsibilities of the role players. e.g. involvement of learners and community in taking care of the trees.
- Select only the best available nursery trees for planting. Take good care of young trees as this will ensure a good yield and quality when they mature and start to produce fruit.
- Most fruit trees perform best in full sunlight. Adhere to the management practices: spacing, fertilisation, irrigation, pruning, pest and disease control etc.
- Some fruit trees need to be pruned during the dormant period while others (tropical and subs-tropical) are normally shaped while the trees are still young and just limited pruning is done at maturity.

Matleu Primary School (Limpopo) is growing variety of fruit trees in the school yard

6.2 Site selection and soil preparation

Suitable localities for growing fruit trees are mainly selected on the basis of long term climatic information and the soil type. (Refer to Section 4.1 on soil properties). After selecting and cleaning the site, the soil must be analysed to determine the pH and nutrient status. If there is a shortage of calcium and phosphate, especially in the subsoil, they should be incorporated into the soil during soil preparation. Lime should be ploughed in during soil preparation.

- Measure the planting distance and dig square holes 60cm x 60cm and 60cm deep for planting.
- Apply the required amount of lime and phosphorus at least 6 months before planting.
- Deep plough the field after fertilizing to loosen the soil to at least 1 meter.
- Construct ridges if necessary.
- If there are many weeds, remove them

6.3 Mixed cropping with vegetables

The most common goal of intercropping is to produce a greater yield on a given piece of land by making use of resources that would otherwise not be utilized by a single crop. Fruit trees are normally planted in rows with the between-row spacing larger than the in-row spacing. The area between rows can be utilised to grow a variety of vegetable crops, especially during the first five years after planting (Figure 6.1). Careful planning is required, taking into account the soil, climate, crops, and pest and disease control methods to be utilised for both the fruit trees and the vegetables.

Do not cultivate the land to a distance of less than 1m to the fruit tree as this might cause damage to the roots of the tree. Vegetable crops planted too close to a fruit tree will also compete with the tree for water and nutrients resulting in poor yield and quality for both crops.

Example of mixed cropping of fruit trees with vegetable

6.4 Planting the trees

Most fruit trees are propagated in a nursery as seedlings or grafted trees in plant bags filled with a growth medium. They are usually purchased from the nursery in plant bags. Correct planting methods and aftercare of the young trees are very important.

- The best planting time is during August-September when natural root growth takes place and the temperatures begin to warm up.
- The orientation of the rows is important in terms of proportional distribution of light on both sides of the row. The ideal is to have a north south row orientation although it might not always be attainable.
- Remove the plastic bag before planting and place the plant together with the soil in the hole.
- Fill the hole with soil round the plant and compact it to the same level as it was in the plant bag.
- Check correct planting depth and spacing when planting.
- Immediately after planting, water trees to saturate the soil.
- When rainfall is not adequate, add water to newly transplanted trees at least once a week during the first growing season.

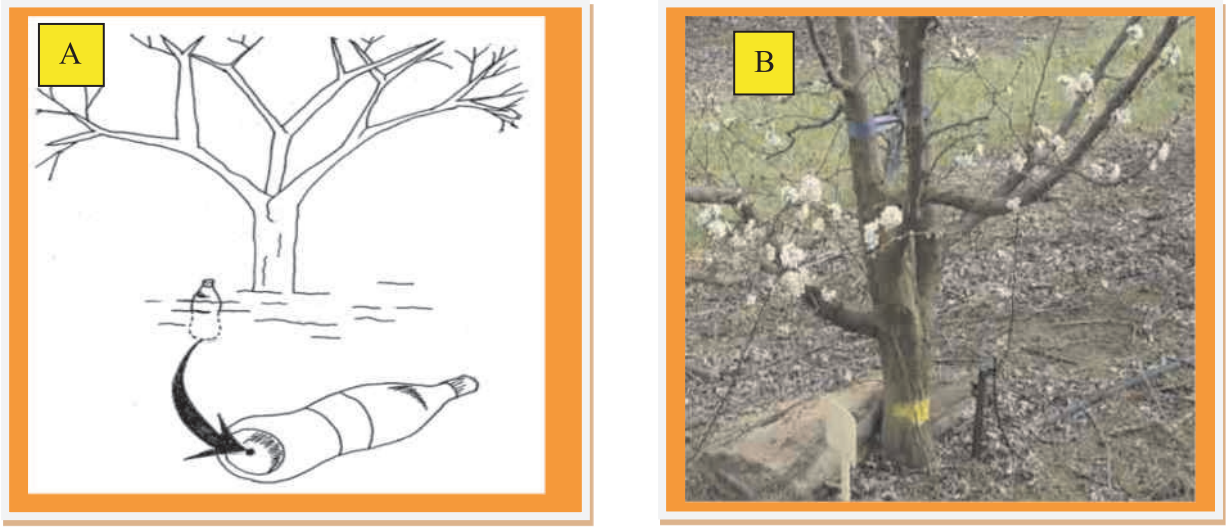
6.5 Irrigation

Most fruit tree crops are sensitive to water stress which affects tree growth, yield, fruit size and quality. Consider the principles for irrigation provided in Section 4.8.

Basic Considerations

- Decide on the best irrigation system (drip, drag lines, etc.) and if possible install before planting.
- Ensure that the water supply and quality is sufficient to meet the requirements of mature trees.
- Schedule irrigation according to the need of the trees (need to adjust according to crop type, the age of the trees, specific requirement, season, soil and climate).
- Some degree of water stress during flower bud initiation may be advantageous but water stress during fruit set and development should be avoided.
- Although certain fruit trees are to some extent drought tolerant it will not achieve optimum growth if they are not irrigated regularly.

Another water saving method is the bottle irrigation system. Make four holes at the bottom of 2L bottle and burry it, up to the neck, 50cm away from the stem of the fruit tree. Fill the bottle with water and turn up the cap lightly. This will allow water to filter through the holes into the root zone. Fill up the water in the bottle at frequent intervals. For larger trees, four to six bottles can be placed for irrigation.



(A) Bottle / Drip irrigation from 2L soda bottle and (B) Use of micro sprayer

6.6 Weed control

Weeds compete with the fruit trees for soil moisture, soil nutrients, light and carbon dioxide. Good weed control is very important in the immediate vicinity of trees to reduce competition Composted mulches are useful for weed control and retaining soil moisture - however soft mulch materials can harbour mice and termites.

6.7 Soil and leaf analysis (established orchards)

Soil analysis in conjunction with leaf analysis provides a good indication of the nutrient status of a tree as well as the actual fertilizer requirements of that tree. A leaf or soil sample should be representative of an area. However, whenever there are visible soil variations, separate leaf and soil samples must be taken and the orchard management adapted accordingly. Leaf analysis is only applicable for producing fruit trees (normally a tree age of 5 years and older) where norms are available. For all other tree crops soil analysis remains the main method to determine the nutrient requirements.

6.7.1 Soil sampling

Before a soil sample is taken, the soil surface must be cleared of debris, leaves and fertilizer.. Take samples by walking diagonally from the corner through the orchard or land (“X” pattern). In an established orchard, soil samples must be taken under the canopy of trees and between the trees in the drip area perimeter. The top and subsoil samples are taken by removing a core of soil from the top (0 - 30 cm) and then from 30 to 60 cm soil depth, respectively. Topsoil and subsoil samples should be taken of the same trees selected for leaf sampling. A soil sample

must not be taken within three months of fertilizing because this will falsify the outcome of the soil analysis. Samples from different fields should not be combined.

6.7.2 Leaf sampling

The time of leaf sampling as well as leaf position is very important. Select about 20 healthy trees by walking diagonally from the corners through the orchard. The trees should be homogeneous in appearance and representative of the orchard. Exceptionally good or poor trees must not be sampled. The selected trees must be clearly marked, for example with paint, so that both the soil and leaf samples can be taken from the same trees every year. Where possible, pick 4 leaves from alternate sides of the tree at about shoulder height/same height. Different cultivars should be sampled separately. Sampled leaves must be free of sunburn, disease and insect damage and be collected in the morning, after the dew has dried off. Leaf samples should not be taken if trees are under stress, i.e. drought or high temperatures. After heavy rains, wait at least 2 weeks before taking samples. After sampling, leaves should be placed in clean, perforated or open plastic bags. If samples cannot be delivered immediately (within 48 hours), they can be stored in a refrigerator and should be transported in a cooler bag. The sample must be accompanied by the relevant orchard information including previous production figures, tree age and fertilizer programmes of the past. Any problems concerning the specific orchard, such as small fruit, should be mentioned.

6.8 Fertilization

Nutrients should only be applied to the drip/irrigated area of a tree. Applying fertilizer close to the roots could result in scorching. Macro-nutrients are mainly applied in the soil while micro-nutrients are sometimes applied by foliar applications. Application rates and time are determined by the nutrient status of the soil and tree, fruit type as well as the age of the tree.

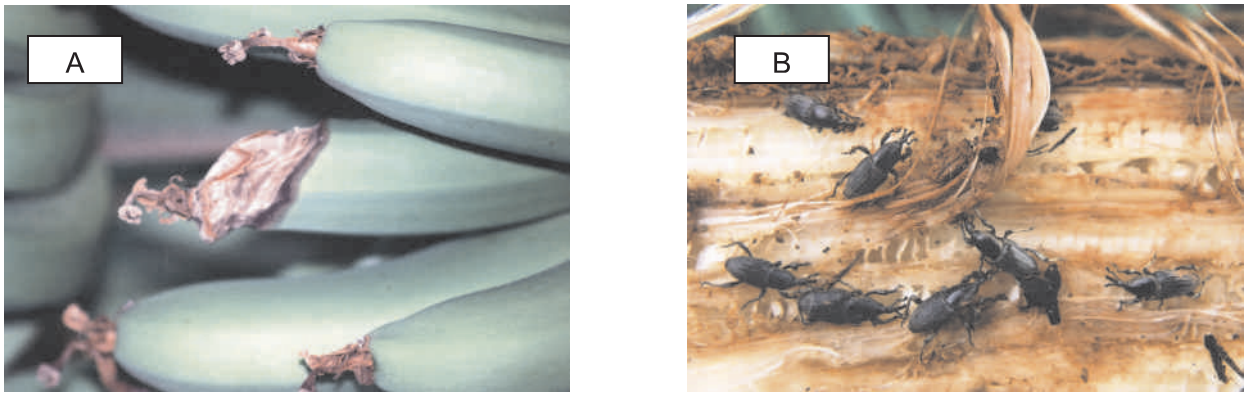
Fertilizers	Application
Insoluble/ partly soluble (phosphate)	incorporated into the soil before planting
Soluble (nitrogen and potassium)	after planting
Nitrogen and Potassium	can be applied as topdressings once trees are properly established and growing vigorously, preferably after 1 year

6.9 Pest and disease control

Growers need to invest in spraying equipment and products. Details of the pests and diseases attacking specific fruit crops are provided in Part 7: Fact sheets on fruit trees.

Remember

- All fruit trees need effective control of pest and diseases
- Spray the products that are registered for a specific purpose on a specific crop at a specific dosage.
- The spray programme should take into account the weather, type and severity of disease/pest, growth stage of the tree as well as the climate.
- The control of pest and diseases should be done timeously in order to avoid damage that might only be visible during fruit maturity.



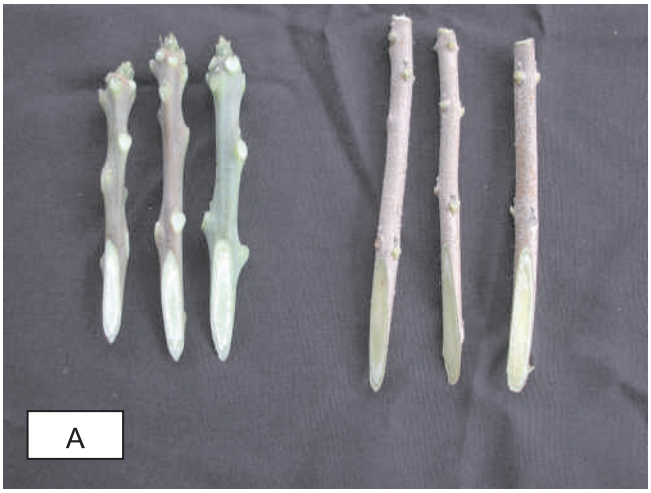
Some examples of diseases and pests on fruit: (A) cigar-end rot of banana, and (B) banana weevil.

6.10 Rootstocks and grafting/budding

Most fruit trees cannot be reproduced "true" to the original cultivar from seed and are commercially reproduced by grafting or budding. For example, the seed from a Fuerte avocado will produce an avocado tree, but it will not produce a Fuerte avocado tree. These seedling trees also take much longer to produce fruit than grafted/budded trees. Grafting and budding are horticultural techniques used to join parts from two or more plants so that they grow as a single plant. The new plant that grows from the scion or bud will be exactly like the plant it came from. For instance, if a Valencia orange is budded onto a rough lemon rootstock the tree will produce Valencia oranges only. These methods of plant reproduction are usually chosen because cuttings from the desired plant root poorly (or not at all). They also give the plant a certain characteristic of the rootstock such as drought tolerance, disease resistance or hardiness. Since both methods require extensive knowledge of nursery crop species and their compatibility, grafting and budding are two techniques that are usually practiced only by more experienced nursery operators.

Grafting and budding can be performed only at very specific times when weather conditions and the physiological stage of plant growth are both optimum. The timing depends on the species and the technique used. In fruit tree crops the main advantages of using a rootstock and scion are tolerance to soil borne and other diseases as well as improved yield and quality. Most fruit trees such as avocado, mango, apricot and peach are grafted, while most citrus are budded on appropriate rootstocks.

An abnormal graft union indicates incompatibility, a poor rootstock or a diseased scion. **A first-grade tree** should have a few leaves on the rootstock below the graft union. Shoots that develop on the rootstock should be removed on a regular basis. Trees should have a uniform appearance and should all be grafted at approximately the same height. Therefore, when selecting a tree from a nursery, check for a good union between the scion and rootstock.



(A) Rootstocks and scion

(B) graft

6.11 Pruning and training

Pruning is the process of removing parts of woody plants such as branches, branch tips, shoots buds or roots and training it to assist the tree to form a desirable shape.

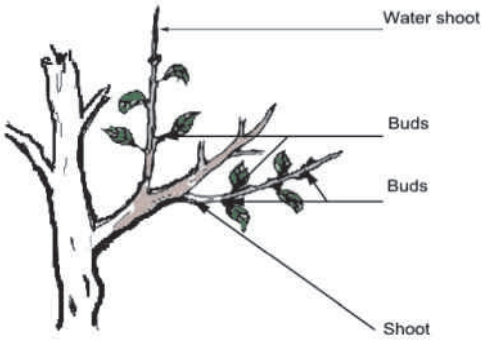
A well-formulated plan, based on knowledge of the underlying principles of pruning, is essential in pruning since no two trees are the same. Pruning skills develop fully with experience and as a person becomes more familiar with the growth and behaviour of the different types of fruit trees and cultivars. Pruning principles will be explained based on temperate fruit crops. The specific pruning of individual species is given in Part 7.

It is very important to prune and train a tree correctly from the first year after planting. Reasons for pruning trees:

- To shape young trees to a particular form and to ensure a strong framework.
- To remove interfering branches in order to allow sunlight and air to penetrate and reach all parts of the tree.
- To remove dead, weak, damaged and diseased branches from the tree.
- To restore the balance between the plant growth above the soil and the roots.
- To rejuvenate mature trees.
- To do early thinning of flower buds.
- To increase the quality and the number of fruits.
- To make thorough spraying of the trees possible.
- To simplify the harvesting of fruit.

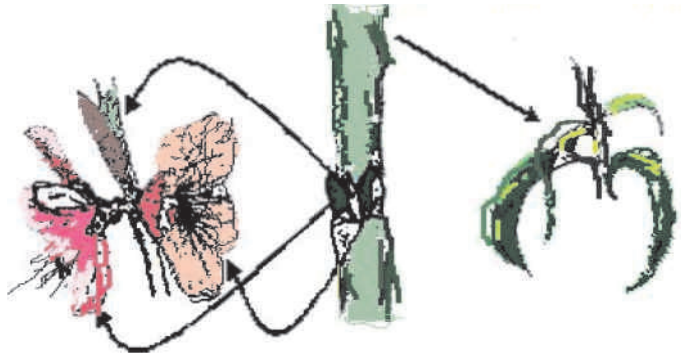
6.11.1 What is a shoot and a bud?

A shoot is a young, growing branch on which flower and shoot buds can be found. A strong, upright growing shoot is sometimes also called a water shoot



Position of water shoot, shoot and buds

Every bud is a potential flower or shoot. There are two kinds of buds namely shoot buds and flower buds. The central bud will develop into a shoot and the outer two buds into flowers (blooms). The flowers will eventually develop into fruit. These three buds are always located on the node of the branch or shoot. The buds located on the internode of a branch or shoot will always develop into a shoot with leaves.



llustration of the position of buds on a branch of a peach tree.

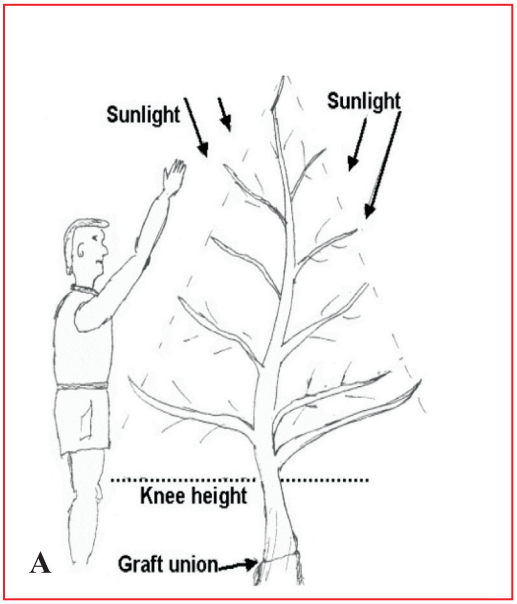
6.11.2 Flower and shoot development

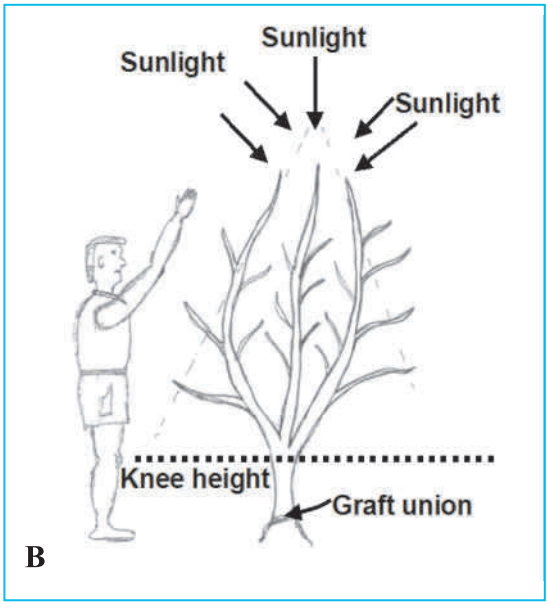
Different types of fruit trees do not produce flowers (blossom) at the same time in different areas. Pruning during the winter normally stimulates new shoot development, while pruning during the summer results in weak shoot growth.

6.11.3 Training systems

There are two major systems used to prune free-standing trees, namely the central leader and the vase (3 leaders) system. Fruit trees can also be trained on a wire trellising system but that is usually used in highly technical, commercial orchards.

The main purpose these systems are to allow enough sunlight to penetrate and reach all parts of the tree. Sunlight is very important for the development of branches (vegetative growth) and flower buds (reproductive development). The figures below illustrate trees that were pruned and trained according to the central leader system and the closed vase system respectively.

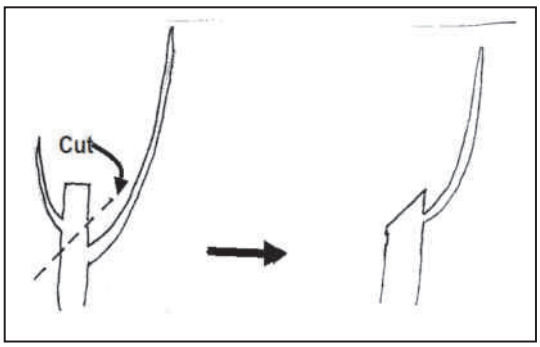




(A)Illustration of a tree that was trained according to the central leader system.
(B) Illustration of a tree that was trained according to the closed vase system.

6.11.4 Important hints regarding pruning

- Prune only during sunny days. This will help to prevent of fungal infection.
- Do not create large pruning wounds during winter.
- Remove injured, dead or diseased branches first.
- Keep your pruning shears clean by disinfecting it regularly during the pruning process. Dip it into a chlorine/bleach solution to disinfect them effectively.
- Make clean, smooth cuts.
- Make the cut at an angle to allow the water to run off.
- Use a sharp saw or pruning shears to prevent the tearing and damage of the tree.
- Cut above a bud correctly as shown in figure below



Correct angle and position to cut a shoot

6.12 Harvesting and post harvest procedures

Though the major goal of school gardens is to develop skills for and to augment school meals, possible markets for excess fruit can be considered. The procedures involved in harvesting are determined by the intended use of the product. For domestic (school) consumption, full ripe fruits can be picked. If fruits are to be sold, the maturity stage at harvest is dependent on the market sector served, the planned storage period, consumer preferences and time of the year.

All fruit must be handled with care to prevent cuts and bruises and packing should be according to the requirements of the intended market.

- Ensure the correct maturity stage of the fruit before harvesting.
- Harvested fruit to be removed from the orchard as soon as possible.
- Grade fruit for marketing according to size and appearance.
- Pick enough fruits for a certain number of learners. When numbers are not enough, different grades may be served the “extra fruit ”on different days.

6.13 Reflection on fruit production

- Determine the suitability of the site for fruit production
  - Collect climatic and soil data for the site
  - Write down the climatic and soil requirements for the fruit trees to be planted
- Decide on what fruit trees to be planted and give reason why
- Soil sampling
  - Collect and mark soil samples as described
- Leave sampling
  - Collect and mark leave samples as described
- Grafting/budding
  - Plant some seedlings to be utilized as rootstocks
  - Do some grafting/ budding

More information on fruits can be obtained from ARC-Institute for Tropical and Subtropical Crops Tel : (013- 753 7000) and ARC-Infruitech Nietvoorbij Tel: (021- 809 3100).

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7. FACT SHEETS ON FRUIT TREES

7.1 Tropical and Subtropical fruit

BANANA

The banana plant (*Musa acuminata*), often referred to as a "tree", is a large herb, with a succulent and juicy stem. Bananas are grown in every humid tropical region and constitute the 4th largest fruit crop of the world, following the grapes, citrus fruits and apples.Growing banana contributes towards food security and it is the stable food in some countries. Selling bananas can generate income for a household or a school, and it can be sold at local markets.

For detailed information: Robinson, J.C. & De Villiers, E.A., 2007. The cultivation of banana. ARC-Institute for Tropical and Subtropical Crops, Nelspruit.

Local names:
Sesotho: Panana **Sepedi:** Panana **Setswana:** Panana **IsiNdebele:** Ubhanana **isiXhosa:** Ibhanana
Tshivenda: Muomva **isiZulu:** Bhanana **Swati:** Bhanana **Xitsonga:** Bhanana

SELECTION OF GOOD QUALITY FRUIT TREES	Banana planting material can be obtained as tissue culture plants, suckers or bits.Tissue culture plants involve the micro-propagation of a sucker growing point under sterile conditions and can be obtained from commercial nurseries.Suckers refer to a detached rhizome in which the central growing point forms the new plant. Bitsare derived from vigorous healthy rhizomes which are too large to use as sword suckers. The rhizome is cut into 2-3 sections (bits), each containing a prominent bud on one side to grow out and produce the new plant.
CLIMATE	Bananas require a warm, humid, frost free climate with the optimum temperature between 22 and 31°C.
SITE SELECTION	Suitable localities for growing banana's are mainly selected on the following guidelines: ● Avoid valley bottoms and lower slopes to prevent chilling from cold air drainage ● Protection or shelter from prevailing winds ● Select suitable and fertile soil
SOIL	The banana root system is very sensitive to compaction thus plantation longevity and sustained high production are dependent on soils which allow unimpeded root extension. Sandy-clay loams are the most suitable soils for banana production. Soil preparation before planting include: ● Measuring the planting distance and digging holes 30 cm x 30 cm and 60 cm deep, remove weeds ● Add kraal manure or compost if available

	Fertilise the soil based on the soil analysis with the recommended amounts of phosphate and lime.
PLANTATION LAYOUT	**Planting the crop** Bananas can be planted using 3 methods: ● Tissue culture plants ● Bits ● Suckers The holes are filled with soil or compost to the correct depth depending on the plant material used. The direction of rows should be from west to east. **Spacing** Space the rows 3 m apart and the plants 1.6 m in the row (2080 plants/ha or 20 plants/100 m^2). **Planting methods for tissue culture plants** ● Tissue culture plants are small plants grown from the tissues of the parent plant in bags, and are ready for planting. ● For hygiene reasons, this is the preferred method for planting bananas. ● The planting depth must be 10 cm. Do not add more than 10 g of Supers into each planting hole. ● Place the plant in the hole with care so that the soil in the bag does not break up. Fill the hole with soil around the plant and compact it. **Planting method for bits and suckers** ● When planting bits, the planting depth must be 10 cm and the bit also about 10 cm^3. Buds on the bits to point the same direction on each plant. ● The planting method for suckers is the same as for planting tissue culture plants.
CROP MANAGEMENT	**Sucker selection** Selection of the correct follower (R1) in a new banana plantation is critical. As a general rule, for a plantation established from September to December, the R1 follower should be selected 5-6 month after planting. All selected R1 suckers must be in exactly the same direction and R2 and R3 ratoon suckers must follow this direction closely. Select only those with narrow leaves, tapered pseudo stems and large rhizomes (sword suckers), and avoid those with broad leaves, narrow, straight pseudo-stems and small rhizomes (water suckers). It is important to keep not more than 20 plants /100 m^2. Therefore, after harvesting only 1 sucker should be allowed to grow. **De-suckering** Unwanted suckers must be removed regularly to prevent competition with the selected sucker. ● From planting until the mother plant is about 1 m high, use a knife to cut off the young suckers at ground level ● Take care not to damage the mother rhizome when de-suckering Continue removing unwanted suckers as they appear.

	Propping bunches The breaking or toppling of pseudo-stems bearing bunches may cause heavy yield losses in a banana plantation. A bunch support system with one or two wooden props with one end embedded in the soil and the other end wedged against the curvature of the bunch stem can prevent the pseudo-stem from breaking under a heavy load. The prop should be clear of the bunch to avoid fruit scarring. **Bunch covers and removal of leaves** Bunch covers should be used for protection against insects and wind and this results in better quality bananas. Remove lower yellowing leaves from the banana plant as they can spread diseases and scratch the bunch.Use a knife to cut off old leaves from the banana plant - do not pull them. Place old leaves on the ground - they mulch the surface, reducing water loss.
FERTILIZATION	In general fertilizers should be applied frequently in small amounts. **Top dressing** The nutrient status of the soil can be maintained by applying nitrogen (N) and potassium (K) topdressings according to the following general guidelines: ***First top dressing*** ● Apply first topdressing a month after planting (January). Use 50 g/plant of LAN fertiliser. ***Second top dressing*** ● Apply second topdressing 3 months after planting (March). Use 100 g/plant of KCl and 50 g/plant LAN fertiliser. ***Third top dressing*** ● Apply third topdressing 5 months after planting (May). Use 100 g/plant of KCl and 50 g/plant LAN fertiliser. ● Do not apply topdressing in June, July and in August. ***Fourth top dressing*** ● Top dress again 9 months after planting in September. Use 100 g/plant of KCl and 50 g/plant of LAN fertiliser. ***Fifth top dressing*** ● Top dress again 11 months after planting (November). Use 100 g/plant of KCl and 50 g/plant LAN fertiliser. ***Last top dressing*** ● Apply the last topdressing in January. Use 100 g/plant of KCl and 50 g/plant LAN fertiliser. ● By making compost heaps from old vegetable leaves, chicken and kraal manure, you can supplement the fertilizer programme.
IRRIGATION	Irrigation should be done according to the soil type, climate and development stage of the plants. A general recommendation in this regard is as follows: ● Water the banana plants directly after planting. ● Irrigate newly-planted tissue culture banana plants every day for 2

	weeks to protect leaves from heat stress. ● In the absence of rain, irrigation water should be applied on a "little and often" basis to banana plants. Thus an irrigation schedule of 15 mm every 3 days in summer and every 6 days in winter is more appropriate.
WEED CONTROL	Weed control can be done by hand, chemicals or both. When chemical sprays are used to kill the weeds, use only recommended chemicals and apply these strictly according to the instructions on the label. Mulching can control weeds and increase productivity significantly.
HARVESTING	From planting to harvesting it takes between 12 and 14 months depending on the climate of the area. From ratoon to harvesting it takes less than a year. **When to harvest** Fruit can be left to become fully mature on the bunch only if the market is close by. Normally fruit is ready for harvest when three quarters round, with some ridges and angles still evident. **Precautions during harvesting** ● Get someone to help in cutting the banana pseudo-stem halfway across and halfway down. ● Do not let bunches fall to the ground. ● Do not pack bunches on top of each other. ● Harvest early in the morning when temperatures are not too hot. ● Build a pack house in a cool location to hang bunches, remove hands, cut into clusters, pack into cartons and store (on southern side).
PESTS	Nematodes, banana weevil, tomato semi-looper, thrips. Control: Plantation sanitation is very important and it is possible to manage most pests within 2-3 seasons by integrating all aspects of cultural control, baiting, and chemical sprays.
DISEASES	Panama wilt, yellow sigatoka, cigar-end rot, cucumber mosaic virus. Control: Use disease free tissue cultured plants as propagating material and remove diseased plants and leaves or parts thereof on a regular basis.

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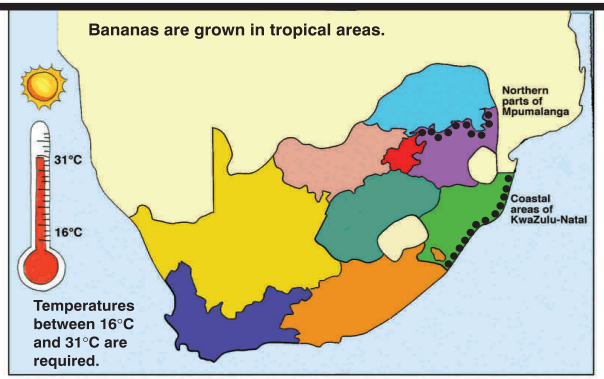
LET'S GROW BANANAS



6 **Irrigation**

Tissue culture plants: 500ml water per plant per day.

Small plants: 1 - 2 weeks after transplanting, 2 - 3 litres water per plant per day.
Adult plants: 15 - 20 litres water per plant per day.

7 **Fertilisation**

One month after planting: add 50g LAN.
Repeat every 6 months (5 times per season).

P & Ca: according to soil analysis before planting.

1 Suckers are removed from the mother plant and then planted. Leave one sucker.

2 Bananas are produced by tissue culture.

They can be purchased from the laboratory.

3 Only one sucker is left in a clump.

4 3m

1.6m

The plants are planted in rows which are 3 metres apart and plants are spaced at 1.6 metres.

5 Plant the suckers in holes.

8 Scout for insects. Combat pests and diseases.

Yellow sigatoka

Cigar-end rot

Banana weevil (12mm)

Nematodes

9 The bunches must be supported.

10 Remove the front portion of the flower once the bunch has formed.

11 Harvest when fruit (finger) is three quarters round and when some ridges are still evident.

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MANGO

The mango*(Mangifera indica)* is an important and very popular subtropical fruit in South Africa with the main production areas in the northern and eastern provinces of South Africa. The production areas are Tzaneen (36%), Hoedspruit (28%), Malalane and Komatipoort (20%). The total area currently under mango production in South Africa is approximately 8 000 hectares and produces just 0,2% of the world production. Less than 10% of the local fruit harvested are exported, whilst about 25% are sold on fresh produce markets. More than 20% are utilised for atchar processing, 15% are dried and about 30% are processed into juice. Ripe mango is a rich source of beta carotene.

For detailed information: De Villiers, E.A. & Joubert, J.H., 2008. The cultivation of mango. ARC-Institute for Tropical and Subtropical Crops, Nelspruit.

Local names:

Sesotho : Menku **Sepedi:** Menku **Setswana:** Menku **IsiNdebele:** Umengu **isiXhosa:** Imengo
Tshivenda: Linngo **isiZulu:** Umango **Swati:** Mangoza **Xitsonga:** Mangos

SELECTION OF GOOD NURSERY TREES	The buyer should have a close look at the trees and select only those of good quality by inspecting the foliage and flowers, internodes, graft unions as well as soil mixture and root system. The foliage of the nursery tree should be glossy and green, giving a general appearance of good health. It is advisable to buy tree seedlings from a reputable nursery.
CLIMATE	Mango trees can tolerate a wide range of climatic conditions. The crop is successfully cultivated under conditions which vary from very hot, very humid to cool and dry.
SOIL AND WATER	**Soil requirements** The taproot can continue growing until it reaches the soil water-table. However, most of the roots responsible for nutrient uptake are found in the top 500 mm of soil, with the largest concentrations in the top 250 mm.The response to the soil type will vary, depending on the conditions under which the mango is grown, i.e. dry land or under irrigation. **Drainage** Mango trees grow best on a slight slope which enables runoff of excess water and prevents water logging. Depressions or basins are poorly drained sites should be avoided.Mango trees do not grow and produce well in soils with impermeable layers (mottled layers, usually with a light grey of white colour, hard banks, and compacted layers of stratified rocks). **Soil depth** Under irrigation, mangoes grow well in soils with an unimpeded depth of

	more than 1 m. **Texture** Suitable soil texture for mango cultivation under irrigation varies from sandy loam to clay loam with a clay content of up to 50 %. **Soil structure** The ideal soil has a fairly loose, brittle, crumbly structure. Compact or strongly-developed soil structures prevent effective water infiltration and root penetration. These soils are normally associated withigh clay content in the subsoil. **Soil pH** Mango trees grow best in soils with pH values of 6 to 7.2. At pH values lower than 6 or higher than 7.2 the trees may suffer trace-element deficiencies, especially phosphate and potassium. **Soil preparation** Soil preparation is essential in order to improve drainage and utilisation of nutrients by the plant. Preparationincludes: ● Measuring the planting distance and digging holes 60cm x 60cm and 60cm deep, remove weeds ● Add kraal manure or compost if available ● Fertilise the soil based on the soil analysis with the recommended amounts of phosphate and lime. **Soil examination** A chemical analysis is necessary to determine lime or phosphate requirements. Soils where mangoes are to be planted should be sampled at least 9 months prior to planting. **Supplying nutrients** Calcium and phosphate move very slowly downwards in soils. If there is a shortage of one of these elements, especially in the subsoil, it should be incorporated into the soil during soil preparation.
CULTIVARS	Important characteristics include: time of ripening, external appearance, fruit size, resistance to bacterial black spot and otherdiseases, tree size and consistent yields. None of the existing cultivars is totally resistant to bacterial black spot. Common cultivars: Tommy Atkins, Keitt, Zill, Kensington, Irwin, Neldica, Sensation, Kent, Heidi
ORCHARD LAYOUT	**Planting time** Although mango orchards are planted throughout the year (especially in the warmer production regions) the best time is August to September. **Tree spacing** For small household orchards a spacing of 6 x 4 m can be utilised.
IRRIGATION	**Water requirements** Young trees should be irrigated daily with 2-3 L of water per day. Mature trees can be irrigated with as much as 70 L per tree per day.
FERTILIZATION	**Macro-nutrients for mangoes under dry land conditions**

<table>
<tr><td></td><td>General fertilization according to tree age in g/tree/year (in absence of leaf and soil analyses):

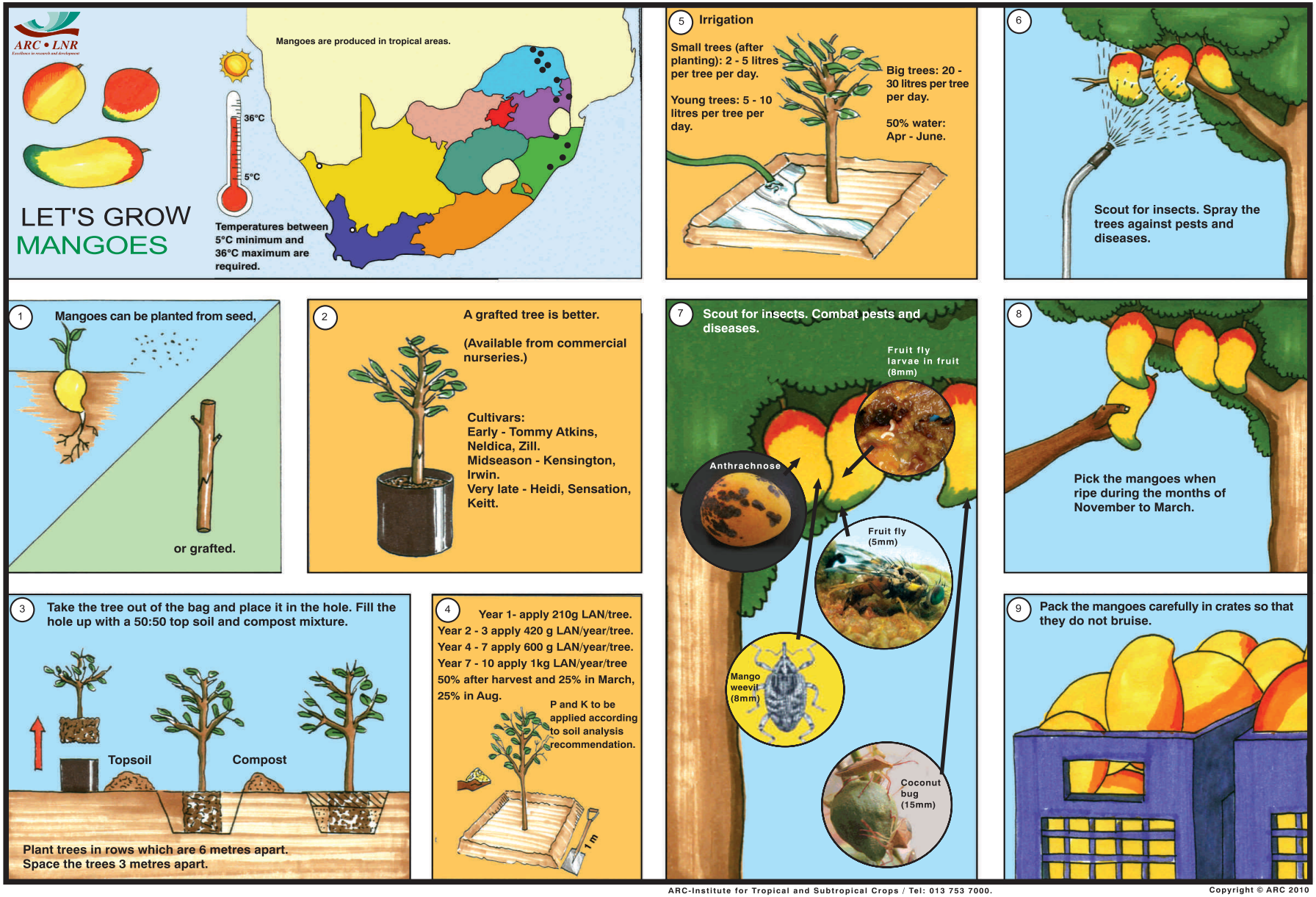
<table>
<tr><th>Year</th><th>Nitrogen (N)</th><th>Phosphorus (P)</th><th>Potassium (K)</th></tr>
<tr><td>1</td><td>70</td><td>25</td><td>200</td></tr>
<tr><td>2–3</td><td>140</td><td>50</td><td>200</td></tr>
<tr><td>4–5</td><td>210</td><td>75</td><td>250</td></tr>
<tr><td>6–7</td><td>280</td><td>100</td><td>375</td></tr>
<tr><td>8–9</td><td>350</td><td>125</td><td>500</td></tr>
<tr><td>10+</td><td>420</td><td>150</td><td>625</td></tr>
</table>
Micronutrients
Micronutrients are essential to all plants and include Zn, B, Mn, Fe, Cu and Mo. Soils suitable for mango production are generally low in zinc (Zn) and boron (B).</td></tr>
<tr><td>HARVESTING</td><td>Grafted trees will bear fruit from an early stage but it is recommended to remove the flowers for the first two years after planting to give the trees a chance to grow vegetatively.

Maturity
Mango fruit is harvested at the so-called mature-green stage. This is the stage of physiological maturity at which ripening will occur, while still allowing time for handling and marketing. Maturity can be measured by using a colour chart and must not be confused with ripeness.

Ripening
Ripening is the process which transforms a mature fruit into an attractive edible one. Ripeness is quite distinct from maturity. A mango may be mature, but not ripe.</td></tr>
<tr><td>PESTS</td><td>Fruitflies, mango weevil, tip wilter. Successful control in mango orchards depends on a combination of the following:

Eradication of invaders (host plants such as bug tree and brambles)
Orchard and yard sanitation by removing on a regular basis all mangoes and other fruit that have dropped in the orchard or yard and destroying these immediately
Hand collection of tip wilters on a regular basis
</td></tr>
<tr><td>DISEASES</td><td>Anthracnose and powdery mildew can be controlled with registered fungicides while cultural practices such as the establishment of wind breaks and pruning of affected twigs can limit bacterial black spot infection.</td></tr>
<tr><td>MARKETING</td><td>Atchar market
Many growers utilise peach, mango trees or other fibrous types for this purpose. The fruit is harvested while relatively small and the seed still soft. Fibreless types can be used for atchar and this often comprises small fruit that would otherwise drop naturally, or fruit where pollination was unsuccessful and the fruit is seedless and likely to drop (mules).

Local market
If fruit is to be marketed locally, it can be allowed to mature for longer periods on the tree.</td></tr>
</table>



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CITRUS

The citrus industry in South Africa is older than 300 years with more than 20 million citrus trees planted on 58 000 hectares. With approximately 1300 producers growing for export and 2200 smaller producers, over 100 000 workers are employed in the sector. Production is split as follows:70% oranges, 16% grapefruit, 7% naartjies and 7% lemons.

Orange = *Citrus sinensis* Grapefruit = *Citrus paradisi*
Naartjie = *Citrus reticulata* Lemon = *Citrus limon*

For detailed information: De Villiers, E.A.& Joubert, P.H., 2006. The cultivation of citrus. ARC-Institute for Tropical and Subtropical Crops, Nelspruit.

Local names: Orange
Sesotho: Lamunu **Sepedi:** Namone **Setswana:** Lamuni **IsiNdebele:** Orantji
isiXhosa: Lorenji **Tshivenda:** Swiri **isiZulu:** Lwolintshi **Swati:**Li orintji **Xitsonga:** Lamula
Local names: Naartjie
Sesotho: Narakisi **Sepedi:** Narakisi **Setswana:** Nariki **IsiNdebele:** Naritjsi **isiXhosa:** Inathisi
Tshivenda: Mbuyu **isiZulu:** Inantshi **Swati:**Linantji **Xitsonga:** Xinarakesi

SELECTION OF GOOD QUALITY NURSERY TREES	Only purchase young trees from a nursery that is registered with the South African Citrus Improvement Scheme. Ask the nurseryman to remove a tree from the bag in the nursery to examine. Wash the potting medium from the roots. Root systems with a mass of fine hair roots (white growth tips) are an indication of good nursery practices. Examine the bark for lesions or spots from which gum oozes - this indicates root rot. Large glossy dark green, well formed leaves indicate a healthy plant. The nursery tree must form a central leader and all side branches that develop on the rootstock or above the bud union to a high of 600mm must be removed.
CLIMATE AND PRODUCTION AREAS	In South Africa the winters are generally cold enough for good-in season crops, especially Valencia's, to set. Navels and mandarins need cooler temperatures to color efficiently and are therefore mainly produced in the Cape province for export. Navel and mandarin, tend to set smaller crops in the warmer parts of the local citrus areas. The coldest month in most of the better navel areas tends to have a mean temperature of 12 to 13°C. Grapefruit require higher temperatures to produce export quality and are mainly produced in Mpumalanga and Limpopo provinces for this purpose (thin skin and high juice percentage). Citrus can be divided into different groups including oranges (navels, midseasons and Valencia;s), mandarins (naartjies), grapefruit and lemons according to their required climatic conditions (production areas) for optimal growth and quality. **Hot production areas** (Thipise, Letsitele, Letaba, Hoedspruit, Swaziland, Malelane, Pngola, Nkwalini) Suitable for the production of high quality grapefruit and Valencia's. To a lesser extend suitable for midseasons and certain mandarins such as Minneola **Intermediate production areas** (Marble Hall, Nelspruit, Karino, Barberton,

SOIL	Letaba, Levubu) Suitable for production of lemons, Valencia and midseason oranges and only marginally suitable for grapefruit (too cool) and navels (to warm). **Cool, inland production areas** (Rustenburg, Lydenburg, Zebediela) Suitable for production of navel oranges and lemons with the warmer and tangelos) **Cold production areas** (Eastern Cape midlands, Sundays river & Gamtoos valley, Western cape and Southern KZN) Suitable for production of high quality navel oranges, mandarins, and lemons with the warmer micro-climates suitable for Valencia production. **Soil requirements** Citrus can be grown in a wide range of soil types provided the soil is well drained. Fertile, well-aerated soils with a pH of between 6 and 6.5 are ideal. The roots of citrus trees normally grow to a depth of 1 m and spread to a width of 2 m beyond the drip line of the tree. If any layers are found within 1m of the soil surface the development of plant roots will be restricted. Over saturation or water logging should also be avoided. Although light soils are considered the best for citrus production, the marginal suitability of some other soil types can be changed to suitable for optimal production by adapted management practices. For example, on heavier soils, drainage can be improved by ridging and even artificial drains. The choice of rootstock should also take the soil conditions into account
ORCHARD LAYOUT	**Planting** Early spring is the best time for transplanting. Planting holes of 0.5 x 0.5 x 0.5 m are prepared and the soil mixed well with 2 spades of compost or kraal manure and 250 g of superphosphate. The young trees are planted to the same depth as they were in the nursery. The bud union should be about 300 mm above the ground level. Once the tree has been planted, the soil must be firmly tramped down. A basin for irrigation is made around the tree which must be thoroughly irrigated immediately after planting. Irrigate again the following day to seal any cracks in the soil. During the first 6 months the trees should be irrigated twice a week and thereafter every 7 days. Labels on trees should be removed since ring-barking of the stem can occur. Young trees need support and stakes can be used, especially in windy areas. **Planting distances** Various factors should be considered when deciding on the optimum planting densities for the different citrus cultivars. High density orchards can only be maintained when good manipulation techniques are in place. For small scale farming and home gardens the following spacing can be considered: Oranges & Minneola - 6 m x 5 m Mandarins - 6 m x 4 m Grapefruit - 8 m x 6 m Lemons - 7 m x 6 m Spacing should be adapted according to the vigour of the scion and rootstock cultivars and prevailing climate.

CULTIVARS & ROOTSTOCKS	There are several cultivars available within each group and only the most common cultivars will be mentioned. **ORANGES (*Citrus sinensis*)** **Navel oranges** Earliest maturing orange variety in South Africa. Only suitable for fresh marketing. Cultivars : Washington, Palmer, Bahianinha, Cara-Cara Rootstocks : X639, Swingle citrumello, MxT, Yuma **Midseasons** Form an important link between the navel and Valencia season. Cultivars: Clanor, Salustiana,Shamouti, Tomango Rootstocks : Troyer & Carrizo citrange **Valencia's** Matures late and have in contrast with navels and mid seasons, a higher heat requirement. Adapted to various production areas and a dual purpose fruit, suitable for processing and fresh marketing. Cultivars : Delta, Midknight, Turkey Rootstocks : Troyer & Carrizo citrange, Swingle citrumello **MANDARINS (*Citrus reticulata*)** **Satsuma –** truly easy peeling, seedless, early maturing Cultivars : Miho-Wase (early), Imamura (late) Rootstocks : Swingle citrumello, Cleopatra mandarin, trifoliate rootstocks **Clementines -** early maturing, seedless, moderately easy peeling Cultivars : Marisol (early), Nules Rootstocks : Troyer & Carrizo citrange **Hybrids –** mandarin x orange/grapefruit hybrids Cultivars : Nova, Minneola tangelo Rootstocks : Troyer & Carrizo citrange, Swingle citrumello **GRAPEFRUIT (*Citrus paradisi*)** Cultivars : Marsh (white flesh, late maturing), Redblush (rose flesh colour, late maturing), Star ruby (dark red flesh, midseason) Rootstocks : Troyer & Carrizo citrange, Swingle citrumello **LEMONS (*Citrus limon*) –** vigorous growers, in contrast to other citrus spp produce a series of flowering flushes throughout the season. Cultivars: Eureka, Lisbon, Eureka seedless Rootstocks: Incompatible with trifoliate rootstocks such as Troyer citrange and Swingle citrumello. Recommended rootstock include Rough lemon and Volckameriana
IRRIGATION	The water required depends on weather conditions. Saturated and poorly-drained conditions could result in root rot, which will shorten the life of the trees. Moisture stress while the tree is flowering during early spring, could result in excessive drop of flowers and fruit-lets, and the resulting crop will be small. A serious drought followed by good rains could produce out-of-season flowering and fruit setting. A lack of moisture during October to January could result in acid fruit. If a sprinkler system is used, about 30 mm of water must be applied every 7 days, depending on the weather.

LEAF AND SOIL SAMPLING

Leaf samples must be taken during the following periods:
Mandarins – end of February
Navels and grapefruit – middle of March
Midseasons and Valencias – middle of April
Mature, 5 to 7- month-old leaves are picked behind the fruit on the fruiting stem. Samples must be delivered to the laboratory for analysis within 2 days of sampling. Every sample must be accompanied by a completed questionnaire, as this information is important for recommendation purposes. Questionnaires are available from the ITSC, Nelspruit.
Leaf samples should be taken annually from the same trees (mark trees with paint).

Soil sampling

A composite sample should not represent more than 3 ha. Samples from different orchards or lands should not be combined. Sampling depth: Topsoil 0 – 300 mm; Subsoil 300 – 600 mm. In an established orchard, topsoil and subsoil samples should be taken at the same trees selected for leaf sampling. Soil samples must be taken under the canopy of trees in the middle between the stem and the drip area perimeter. Topsoil and subsoil must be packed separately and the depth of sampling, orchard/land must be indicated clearly.

FERTILIZATION

Fertilization should be done according to soil analysis results. During the first year, nitrogen may be applied every 2 months. Fertilizer should be spread evenly under the canopy of the tree and irrigated. The following table can be used as a general guideline and indicates how the fertilizer requirements of growing citrus trees increase (kg/tree/year).

	Type of fertilizer				
Age	3:1:5(38)	5:1:5(45)	LAN(28)	Supers(10.5)	KCL(50)
1	0.5	-	0.15	0.20	0.20
2	0.9	-	0.30	0.40	0.20
3	1.3	-	0.50	0.60	0.30
4	1.8	-	0.75	0.80	0.50
5-6	-	2.0	1.20	1.00	0.75
7-8	-	2.5	1.80	1.25	1.00
9+	-	3.0	2.10	1.50	1.50

Deficiencies of zinc, copper and manganese often occur and may be applied in 10 L water at the following concentrations:
15 g zinc oxide
20 g copper oxychloride
20 g manganese sulphate.
The micronutrient solutions should be sprayed during early spring when the leaves are actively growing. A bdron eficiency can be rectified by spreading 20 g borax per large tree under the canopy or by spraying with a solution of 10 g solubor/10 L water.

WEED CONTROL

It is very important to keep the area under the canopy free of weeds. Weeds may be removed by hand. Be careful not to damage the shallow feeder roots or the trunk when spades or other tools are used. Wounds promote penetration of soil pathogens which cause root rot. Weeds also act as pathways for ants.

HARVESTING	Citrus trees take 3-4 years to the first harvest if grafted. Seedlings can take 6-8 years to the first harvest. The fruit can be removed from the tree by clipping the stem or by snap picking. In addition to clippers, pickers must have picking bags and ladders. Citrus is sensitive to a disorder called oleocellosis, in which the oil glands in the rind rupture as a result of excessive turgidity caused by wet conditions during harvest. Harvested fruit are transported to the packhouse where it is treated with a fungicide near the end of the washing line. All harvesting and packing equipment must be kept clean to ensure it is not a source of fungal infection. A wide range of packing material, depending on the market, is available.
PESTS	The use of pesticides in the home garden should be restricted to a minimum. There is a balance between pests and their natural enemies. When pesticides are used unwisely, this balance is disturbed and a vicious cycle is created. Citrus nematode **-** control include removal of old citrus roots in re-plant soils, decontaminated irrigation water, tolerant rootstocks and chemical control. Red scale and soft brown scale is controlled satisfactorily by natural enemies, provided that ants are kept out of the trees. Citrus thrips - Preventative chemical control at 80 – 100% petal fall is very effective. Orange dog - Hand collecting of larvae on young trees and nursery material are mostly efficient**.** False codling moth - Remove and destroy all dropped and infested fruit from the trees weekly. Also remove all out-of-season fruit in November and again once the fruit has been harvested.
DISEASES	Fungal diseases such as Black spot and Scab where control is based on chemical programs while *Phythopthora* root (*P. citrophthora*) and collar rot (*P. paracitica*), Greening and Tristeza could be limited by buying only trees from registered nurseries, ensuring optimal irrigation practices and controlling aphids.

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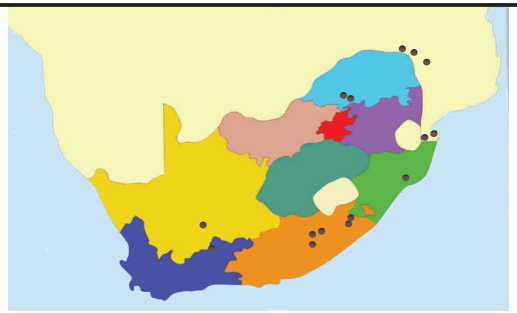
LET'S GROW CITRUS FRUIT

Citrus fruits are grown in cool semi-coastal areas of eastern and western Cape, areas of Limpopo, Mpumalanga, KwaZulu-Natal, Nelspruit and Letaba.

Cultivars:

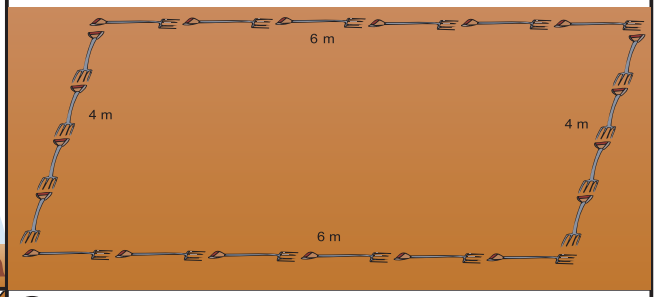
Sweet oranges
Mandarins
Grapefruit
Lemons



REMEMBER: Order your fruit trees from the nursery a year in advance!

1 Take a soil sample and have it analysed to know how much fertiliser is needed.

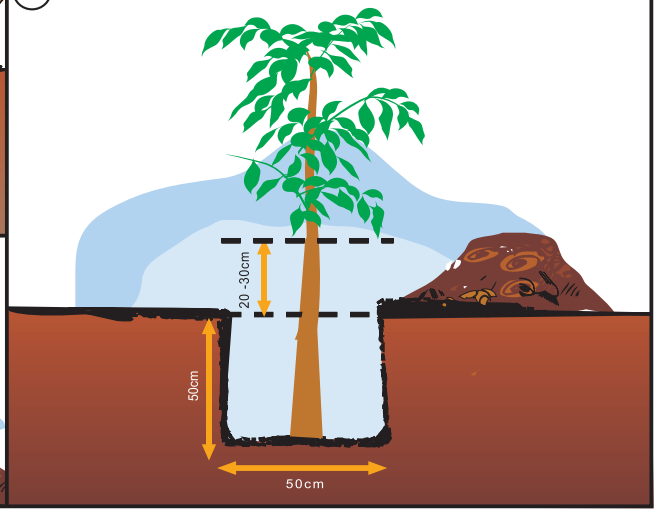
2 A general spacing of 6m X 4m can be used for oranges and mandarines.



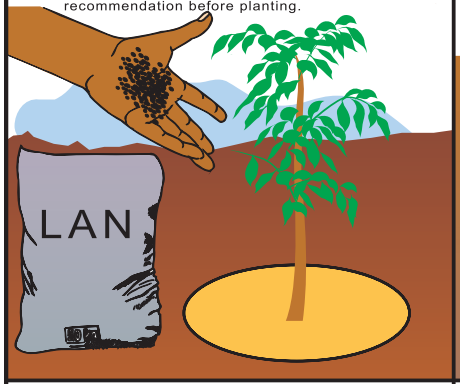
3 Prepare a hole of 50 X 50 X 50 cm.

4 Mix 2 spades full of compost and 250g Superphosphate per hole.

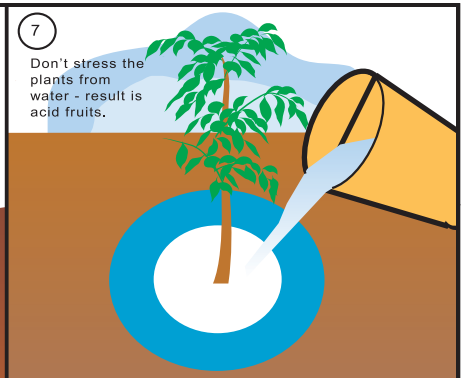
5 Check bud union 20 - 30cm above ground level.



6 Topdressing: For 1st year: every 2 months apply 25g LAN per tree per year.
From 2nd year: twice a year July and March.
Add other elements according to soil analysis recommendation before planting.

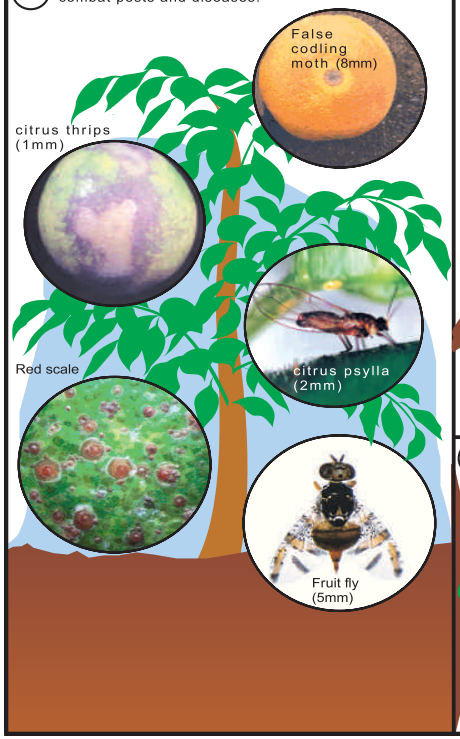


7 Don't stress the plants from water - result is acid fruits.

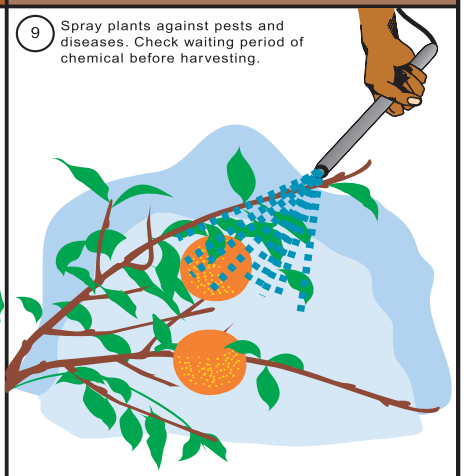


After planting: 2 - 3 litres/tree for 2 weeks.
Young trees: 10 - 30 litres/tree/day.
Mature trees: 60 - 100 litres/tree/day.
Oct - Jan: critical to get enough water.

8 Visit your trees weekly, scout for insects and combat pests and diseases.



9 Spray plants against pests and diseases. Check waiting period of chemical before harvesting.



10 Harvest the crop and grade according to size and quality.

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GRANADILLAS

South America is the true home of 95% of all granadillas (also called passion fruits). Although they originated in the tropics, many species are remarkably tolerant of subtropical and even temperate climates. In South Africa the granadilla is cultivated commercially largely for processing but the best quality fruit are sold on the fresh fruit market. The purple granadilla is locally grown commercially as well as for home use in most of the provinces. The purple (*Passiflora edulis*) and yellow (*P. edulis forma flavicarpa*) are mainly cultivated in South Africa.

For detailed information: De Villiers, E.A. & Fraser, C., 2000. The cultivation of granadillas. ARC-Institute for Tropical and Subtropical Crops, Nelspruit.

Local names:
Sesotho: Granadella **Sepedi:** Granadilla/Keranatila **Setswana:** Granadilla/Keranatila
Tshivenda: Furannda **isiZulu:** Granadila **Swati:** Liganandela
Xitsonga: Magirinandela

SELECTION OF GOOD QUALITY PLANTS	Granadillas can be propagated by means of seed, cuttings or grafting onto a rootstock. Most of the commercial plantings in South Africa originated from seedlings. ● Collect only seed from plants that are at least 2 km away from other *Passiflora* species ● Use seed of ripe, well filled, true to type fruit selected from healthy plants ● Propagation by cuttings is not a common practice in South Africa because of the danger of transmitting viruses ● The yellow granadilla is reported to be tolerant to stem and root rot fungi as well as nematodes and therefore utilised as rootstock for the purple granadilla ● The optimum time for transplanting is August/September ● Select only vigorous, healthy seedlings for transplanting.
CLIMATE	Granadillas prefer moderate temperatures throughout the year and should not be grown commercially areas with severe frost. In hot areas, they should be planted on cool slopes and in cool areas on the warm northern slopes. The average maximum monthly temperature should not exceed 29°C and the minimum should not fall below 5°C. Granadillas prefer a high relative humidity and well-distributed rainfall of not less than 1 200 mm/year (irrigation can supplement low rainfall). Windbreaks are advisable. Granadillas are produced in the sub tropical areas of the eastern part of South Africa from Levubu in the north to Port Elisabeth in the south. There are also commercial orchards in the high veld in Bela Bela, Brits and Groblersdal as well as a few in the western Cape in Clanwilliam, Porterville and Wellington area.

SOIL	Deep soil preparation is important because granadilla plants develop shallow root systems in compacted soils. Thorough soil preparation will also improve drainage. Because granadillas are sensitive to excessively wet soil conditions it is best to avoid clay soil. Soil preparation should be as deep as possible, and not less than 800 mm. Lime and phosphate (if necessary) should be incorporated into the soil during soil preparation. The ideal soil is well drained with a clay content of 10-30% and no impermeable layers within 800 mm from the soil surface.
CULTIVARS	The yellow granadilla is more susceptible to cold than the purple granadilla and grafted plants should therefore not be planted in areas where frost occurs.
IRRIGATION	The maximum water requirements are approximately 50 m^3/ha/day or 15 L/plant/day in summer and approximately 25 m^3/ha/day or 8 L/plant/day in winter. Since the crop produce virtually throughout the year it is important to obtain an optimum soil-water status throughout the season. Avoid over irrigation because it could enhance the multiplication and distribution of fungi. Drip irrigation is particularly suitable for the irrigation of granadillas.
LEAF AND SOIL SAMPLING	Sample the correct leaf i.e. the leaf adjoining the first open flower (generally the 8th leaf from the tip of the runner). Select only leaves of healthy plants without sunburn, disease or insect damage. Soil samples can be taken at the same time in the wetting and fertilizer zone of the same plants.
FERTILIZATION	The recommended fertilizer programme for granadillas is given in the table. These are only general guidelines and should be supported by soil and leaf analyses. **Fertilization according to plant age (g/plant/year)** **Age** / **LAN** / **Single superphosphate** / **KCl or K2SO4** 1st year / 250 / 150 / 150 / 180 2nd year / 350 / 300 / 300 / 375 3rd year+ / 450 / 450 / 450 / 540 **Time of application** July to August: ⅓ of the nitrogen + all the phosphate + ½ of the potash (K) December: ⅓ of the nitrogen + ½ of the potash April: ⅓ of the nitrogen Granadillas often have a zinc and boron deficiency. Zinc oxide can be added at 200 g/100 L of water, or Solubor at 100 g/100 L of water. Spray especially new growth during spring.
WEED CONTROL	It is very important to keep the area in the rows free of weeds. Weeds may be removed by hand. Be careful not to damage the shallow feeder roots or the trunk when spades or other tools are used. Wounds promote penetration of soil pathogens which cause root rot.
HARVESTING	Depending on the time of transplanting, the first fruit is usually ready for harvesting 6 to 9 months after planting. At about 18 months after planting the crop should have reached its full bearing potential. Thereafter, there are 2 main crops annually, namely a summer crop from November to January and a smaller winter crop during June and July. In the Northern Province and Mpumalanga growers sometimes have a third crop during March and April. A limited quantity of fruit will, however, be available throughout the

	year. Fruit can be picked 2 to 3 times a week in summer when fully developed and with a light purple colour. Fruit with deep purple colouris ready for consumption. During the cooler months fruit is harvested weekly.
PESTS	Granadillas are relatively free of pests, but these do occur from time to time and it is important to know which pests can be expected. **Thrips** New growth is sometimes severely attacked, causing leaves to become misshapen and curled. Chemical spray with mercaptothion WP @ 350 g or EC @ 175 ml /100 L water. **Jointed pumpkin fly (*Didacus vertebrates*)** Attacks very young fruit which then drop a couple of days later. Controlled by a bait spray with mercaptothion WP @ 350 g or EC @ 175 ml plus 8 kg sugar /100 L water. **Stink bugs and top wilters** Stink bugs feed on the green fruit resulting in feeding marks on the outside and a hard lump on the inside. Tip wilters attack both the young and older plants at the growing tips. Field inspections and collecting the insects can assist in controlling them. **Nematodes** Seed from virus free mother plants should be propagated in a sterilized medium. Strip fumigation can be used to control nematodes before planting.
DISEASES	**Damping offof seedlings** A complex of fungi may occur on plantsincluding, *Pythium, Fusarium*, and *Rhizoctonia*, often as a result of poor seedbed management. Plant on a well-drained site in virgin soil, or sterilised soil or growth medium. Treat seed with fungicide before planting. **Sudden wilt and Foot rot (*Fusarium solani*)** The base of the stem thickens, causing cracks in the soil surface through which numerous secondary organisms can enter, resulting in total rotting of the stem. Water logging and over irrigation increase the incidence of the disease. Plant in well-drained soils. Use chemical methods of weed control to avoid mechanical injury to the stem. **Leaf and fruit spots** The most prominent fruit spot in South Africa is caused by the fungus *Septoria* which can occur at any stage of development. Spots are greyish tan with a dark green water soaked halo. Thinning the vines to promote air flow and fast drying will reduce disease pressure. **Virus complex** Various viruses may infect plants, causing symptoms such as spots, mosaics and distortion. It is usually very difficult to identify the specific virus involved. In general viruses are not transmitted by seed. Affected shoots can be broken off the plant. Frequent washing of hands during harvesting reduces transmission. Wipe pruning instruments with 10% of a household bleach after pruning each plant.

PAPAYA

The papaya (*Carica papaya*)is mainly cultivated in the eastern and north-eastern Lowveld, KwaZulu-Natal and to a lesser extent in the Eastern Cape. Trees are fast growing. In tropical conditions they flower within 6 months after planting and will continue flowering throughout the year. Papayas are growing in popularity in the Western world because of the high nutritional value of the fruit and the beneficial effects on digestion. Ripe papaya is a good source of beta-carotene.

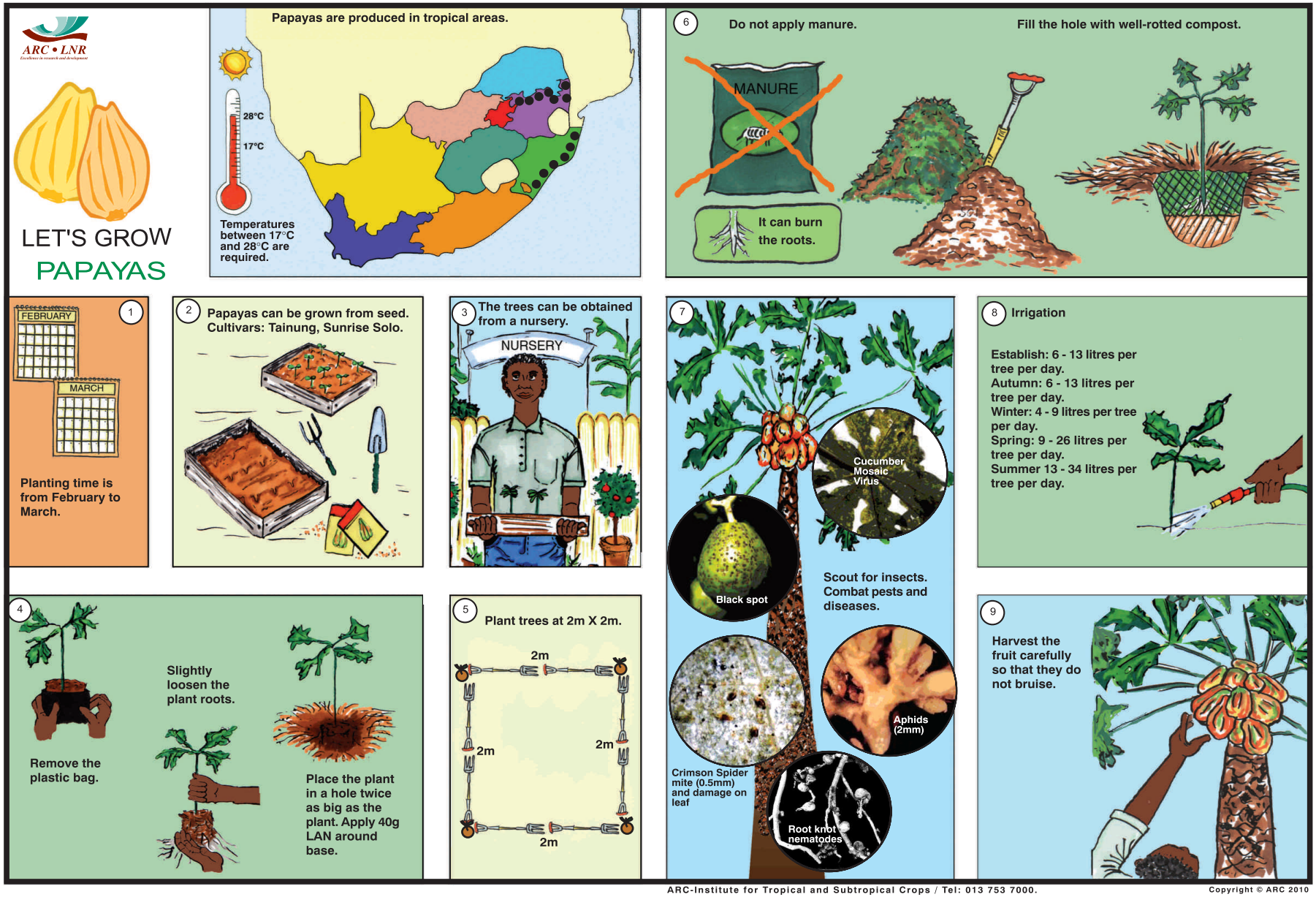
For detailed information: De Villiers, E.A., 1999. The cultivation of papaya. ARC-Institute for Tropical and Subtropical Crops, Nelspruit.

Local names:
Sesotho: Phopho **Sepedi:** Phopho **Setswana:** Phopho **IsiNdebele:** Ipopo **isiXhosa:** Ipopo
Tshivenda : Papawe **isiZulu:** Upopo **Swati:** Liphopho **Xitsonga:** Pawpaw

SELECTION OF GOOD QUALITY TREES	The common name papaya refers to the species name *Carica papaya*.The term "papino" is used to refer to small pear shaped fruit of cultivars such as Sunrise Solo and is only a brand name with no botanical reference. *Carica papaya* has three basic sex forms namely female, male and hermaphrodite. The different sex forms give rise to two types of papayas commercially grown, namely solo (or hermaphrodite) varieties, like Sunrise Solo and the dioecious varieties, such as Hortus Gold. Always select only healthy trees without any visible disease and/or insect damage. The type of papaya and cultivar to select depends on the average minimum temperature of the region. In general hermaphrodite cultivars need a higher minimum temperature to produce a satisfactory crop.
CLIMATE	The papaya is a tropical plant with growth and development severely affected by temperatures below 12°C. Although a mature papaya tree can withstand a temperature of – 2°C, commercial production is only recommended in areas where the average daily minimum temperature during midwinter never drops below 5°C.
SOIL	Papayas grow best on soil with a slight slope, because it enables the runoff or drainage of excess water and therefore prevents water logging. Impermeable layers in the soil adversely affect growth and production of the plant and can lead to infection with root diseases. The ideal soil texture for papaya cultivation under irrigation is a sandy loam or loam soil (i.e. with a clay content of 15 to 30%). Proper soil preparation will ensure optimal conditions for root growth which can last for the lifespan of the plantation and may include deep plough or rip as well as the building of ridges if necessary.
CULTIVARS	The target market is the most important consideration when choosing a cultivar. For export, small fruit (300 - 500 g) with an outstanding shelf life is required. Presently, Sunrise Solo, Baixinho and to a lesser extent Af-1, are suitable for export. Chain stores require fruit with a good shelf life and for pre-packs, fruit not bigger than 1 200 g. The Tainung varieties as well as Sunrise Solo are suitable for this purpose. The fresh produce markets and

	farm stalls prefer bigger fruit such as the Tainung varieties and Hortus Gold types such as FI-2. In general the hermaphroditic cultivars, such as Sunrise Solo, are not suitable for cooler production areas with mean minimum temperatures lower than 17°C during the winter.
ORCHARD LAYOUT AND CROP MANAGEMENT	Growing seedlings is the easiest and most economical way to propagate papayas. For plantings in March/April seeds are sown in January/February. **Time of planting** Different planting times will have an effect on the size of the tree when the first fruit sets. The best planting time for papayas is during late summer and autumn (February/March), except in areas where winter temperatures drop to below 6°C. The plants will then mature before and during winter, but the growth will be retarded, so that when the plants start to flower in October the flowers will be nearer to the ground, enabling the harvesting of more papayas from the trees without using ladders. **Planting method** The plants must be planted as upright as possible or the tree will lean over for the rest of its life. **Dioecious trees** Since only the female trees will bear fruit it is important to have the minimum required number of male trees in a planting (one male to every 25 females). **Hermaphrodite trees** Each plant has the potential to bear fruit, so only one plant per hole is necessary. **Planting densities and layout** The most often used system in South Africa is the tram line system. In general the between row width should be about 3 m with the tramline spacing adjusted from 2 m x 2 m; 2.5 m x 2.5 m or 3 m x 3 m according to the growth habit of the plants. **Windbreaks** In areas subjected to wind it is advisable to make provision for windbreaks.
PETIOLE AND SOIL SAMPLING	A soil analysis will indicate the availability of nutrients in the soil. A petiole sample provides information on the uptake of nutrients by the plant. The correct procedure for soil and leaf-petiole sampling is a prerequisite for accurate analytical results. **Petiole sampling** Select the petiole of the youngest fully-expanded mature leaf beneath the most recently opened flower during November. It is important to note that the sample does not include the leaf. **Soil sampling** A soil analysis will only indicate the chemical composition of the soil. If a soil tube or auger is not available a spade can be used,with two containers, for the top and subsoil respectively.
FERTILIZATION	Because lime moves slowly in the soil, it must be broadcast and incorporated into the soil to a depth of at least 500 mm before planting. **Phosphorus (P)** remains in the soil for a long time and because the P requirements of papaya plants are relatively small, growers must avoid over application of this element. An annual maintenance application of 450 g superphosphate per tree during spring from the second year after planting is recommended. If, however, soil and petiole sampling indicate that these levels are high, P fertilisation should be reduced or stopped. **Nitrogen (N)** Once papaya plants are established and growing actively, apply 60 g LAN every 6 weeks during the first year. Thereafter apply 120 g

	LAN every 2 months during the active growing period (between about September and April. **Organic fertilizer** such as kraal manure improves the physical and biological properties of the soil. For mature plants kraal manure could be applied at 10 to 20 kg/tree as a supplement to inorganic fertiliser. Do not apply manure within 300 mm of the trunk. **Potassium (K)** As a guideline, maintenance K applications of 150 g potassium chloride (KCl) or 180 g potassium sulphate (K_2SO_4) /tree per year during the first year and 200 g KCl or 240 g K_2SO_4 during the second year are recommended. Apply about 40% of the fertiliser during the vegetative phase and 60% during the fruit growth and development phase.
IRRIGATION	General guidelines for the total water requirements (rainfall included) of papaya trees are as follow: Time of year – Litres/tree/day – Time of year – Litres/tree/day Establishment – 6–13 First autumn – 6–13 – Second autumn – 9–17 First winter – 4–9 – Second winter – 6–13 First spring – 9–17 – Second spring – 13–26 First summer – 13–26 – Second summer – 17–34
WEED CONTROL	Weeds under the trees can be controlled mechanically by hand hoeing. In the case of a tramline planting (with a working row area which allows tractor movement), mechanical mowing by means of a rotary cutter (slasher driven by a tractor) can be used. Various organic as well as inorganic mulches can be used in tree orchards.
HARVESTING	As with most fruit tree crops the procedures involved in the harvest and post harvest handling of papayas are determined by market requirements and cultivars. **Maturity** Depends on the intended storage period, specifications of the client. In general fruit should be harvested at the “yellow break” stage – that is when the first streak of yellow appears on fruit. **Method** In the peak season fruit should be harvested three times a week with a 20 mm portion of the stem attached. Fruit must be packed in a single layerin a lug box with the stem end resting on the bottom. The bottom of the lug box should be covered with paper woolor any other non-contaminated material that can absorb latex. The latex should therefore be allowed to drain from the stem end onto the paper wool where it will be absorbed.
PESTS	Bagrada bug and aphids can be controlled by regular inspections in the young orchard and spraying with mercaptothion WP at 250 g/100 L water.
DISEASES	Damping off of seedlings, powdery mildew, black spot, root rot and virus diseases. The implementation of a thorough orchard sanitation programme can limit the incidence of leaf and fruit diseases. Old and infected leaves and spoilt fruit must be removed from the orchard and be destroyed elsewhere. Virus infected plants should be destroyed because they act as sources of infection to other plants. Root rot can be prevented by good soil drainage and by avoiding mechanical damage to the roots or stem base.



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PEACH

Peaches (*Prunus persica*) were first cultivated in China. It is said that travelers along caravan routes carried the peach seed to Persia and Europe.Peaches were most probably introduced to South Africa by the colonial settlers.Tree census data from 2008 indicated that there were more that seven million peach trees planted in commercial orchards in South Africa. Peaches contain antioxidants e.g. healthy portions of vitamin A, vitamin B_1, vitamin B_2, niacin, calcium, phosphorus, iron, and potassium.

Local names:

Sesotho: Perekisi **Sepedi:** Perekishi **Setswana:** Perekisi **IsiNdebele:** Peregithji
isiXhosa: Ipesika **Tshivenda :** Beregisi **isiZulu:** Ipentshisi **Swati:** Lipenjisi **Xitsonga:** Perekixi

SOIL	Peach trees require deep, well-drained soils with clay content between 10% and 35%. Soils with high clay content or waterlogged soils should be avoided. Any limiting soil layers, such as compacted or very clayey soil layers, should be identified as these layers will prevent water drainage and limit root development. The effective depth of the soil should at least be 600 mm while a pH of 6.5 is ideal. Soils where nematodes are problematic should be avoided. It is advisable to make soil profile pits before a decision is made on the suitability of the soil. A soil sample should be taken from these pits and send to a reputable laboratory to determine the nutrient content and suitability for peach production. At least six such soil samples per hectare should be taken. The soil profile should also be examined for any limiting layers which will determine the method to be used in preparing the soil.
CLIMATE	Peach trees require sufficient low temperatures during the winter (winter chilling) to enter into their rest period (or winter dormancy). Dormancy is a developmental phase of the tree which occurs annually and is necessary as it allow the trees to survive unfavourable winter temperatures. The trees enter into the dormant state as soon as cooler temperatures are experienced during autumn. The minimum air temperatures during this dormancy period should be between 2.5 and 12.5^{o}C for a period of approximately 850 to 1000 hours during the months of April to August. The trees will remain in this state of dormancy until they have been exposed to a specific amount of winter chilling and will only bloom when they experience warmer temperatures during spring. Annual rainfall should be taken into consideration in planning a peach orchard as it could affect the fruit quality negatively. The amount of rainfall would also determine the amount of irrigation that should be applied to supplement the water requirement of the trees. The occurrence of rainy, windy conditions during flowering will lead to poor fruit-set as the pollinating agents (bees) would not be able to operate.

CULTIVARS	Low lying areas, areas with unusually low temperatures or area prone to frost during late spring should be avoided when selecting cultivars which are sensitive to frost. Cultivars that blossom late should be selected for these areas. The cultivar's chilling requirements and time of blossoming, climatic variations throughout the year, susceptibility to diseases and cross-pollinator requirements and future market should also be taken into consideration when selecting a cultivar. There are currently more than 33 different peach cultivars which are commercially planted in the Republic of South Africa. More information can be obtained form ARC Infruitec-Nietvoorbij. Most of the newer cultivars in South Africa have Plant Breeders Rights and are therefore protected by legislation against illegal propagation. However, there are enough old open cultivars such as Elberta, Kakamas, Malherbe, Neethling and Oom Sarel that can be purchased. It is also important to keep in mind that some of these open cultivars might not be suitable for certain areas. In order to ensure that the trees are true-to-type and disease free, one should be purchased the trees from a respectable registered nursery.
PLANTING TIME	The best time to plant is when the trees are still dormant, i.e. late July to mid August.
PLANTING METHODS & PLANT DENSITY	There are certain aspects which should be taken into account before the trees are established, namely: slope, plant spacing/planting density and planting depth. **1. Slope** Cold air pockets will occur in low-lying areas such as the bottom of a valley. It is important to remember that cold air is heavier than warm air. The cold air will accumulate in the lower-lying areas of an orchard which could lead to frost damage. This should be kept in mind when establishing peach trees in areas that are prone to frost. It is always best to plant the trees on the northern slope and to orientate the tree-rows in a North-South direction. **2. Plant spacing** Peach trees normally have a life span of 15 to 20 years. It is therefore important not to plant the trees too close to each other. Peach trees are normally planted 2.5 m apart within the planting row and at a spacing of 4 to 5 m between the planting rows. However, the planting density will depend on the existing irrigation system and size of the implements that would be used, such as tractor and spraying equipment. Plant density also depends on the properties of the selected rootstock and the training system which will be used. The growth habit, i.e. upright or spreading, will also determine the plant spacing. **2. Plant depth** Nurseries usually sell open-rooted trees in bundles of 20 to 25 trees. The roots should be covered with moist wood chippings when it is transported from the nursery to the farm. This step is essential to prevent the roots from drying out. The planting holes should be made to the same depth as they have been in the nursery, provided the soil was prepared properly in advance. However, if the soils have not been prepared in advance, i.e. house gardens, it would be necessary to make larger square planting holes: 1 m x 1 m x 800 mm deep. The walls of the planting holes should be roughened in order for the plant roots to penetrate the soil adjoining the planting hole. Specific amounts of lime, phosphorous, potassium and micro-elements, based on the soil analysis, should be applied to the soil and mixed thoroughly. The roots should not get into contact with any fertilizer or manure which was applied into the planting hole as the roots might get scorched.

<table>
<tr><td></td><td>The trees should be planted with the bud-union of the tree approximately 5 to 10 cm above the soil surface. The soil should then be packed firmly around the roots and irrigated directly after planting. Care should be taken not to compact the soil in the planting hole as it would have a negative effect on the soil aeration which will in turn result in poor root development. It is important to trim the central, leading branch of the tree directly after planting to approximately 20 to 30 cm above the graft-union (±70 cm above the soil surface). Depending on the training system, the tree should be allowed to develop 3 to 4 well-positioned branches which will eventually form the main scaffolds.</td></tr>
<tr><td>FERTILIZATION</td><td>The fertilization program should be based on the results of the soil analysis. Factors such as the removal of the soil's nutrients by the crop, effective application of fertilizers to the soil and fertilizing according to the expected production, should be taken into consideration.
Peach trees are deciduous, in other words, they shed their leaves every year during autumn. The amount of fruit on the tree, the growth of the trees and the concentration of the nutrients in the fruit and the rest of the tree will determine the amount of the nutrients that was removed during harvest and autumn. The nutrient status of the soil as well as of the trees can only be determined by analyzing the soil and leaves. Soil samples should therefore be taken prior to soil preparation and every three years after planting. Leaf samples on the other hand should be taken annually during January. Phosphorous are applied during soil preparation.
Specific amounts of lime, phosphorous, potassium and micro-elements, based on the soil analysis, should be applied to the soil and mixed thoroughly. However, as a rule of thumb one handful of bonemeal plus one bucket full (5 liter size) of compost OR one matchbox of Superphosphate plus one bucket full of compost can be applied preplant. A general guide for the application of fertilizers thereafter, are indicated in the Table below.
<table>
<tr><td>Tree age (year)</td><td>Amount of nitrogen (gram/tree/month)</td></tr>
<tr><td>1</td><td>30</td></tr>
<tr><td>2</td><td>60</td></tr>
<tr><td>3</td><td>90</td></tr>
<tr><td>4+</td><td>Amount must be determined by the results of the soil and leaf analysis.</td></tr>
</table>
Fertilizers are quite expensive and some of them such as nitrogen leach readily from soils. It is therefore of the utmost importance to ensure that the fertilizers are applied in the correct way and that the correct amounts of fertilizer are applied.</td></tr>
<tr><td>IRRIGATION</td><td>The soil type, the quality, availability and accessibility of water, the climatic conditions, the age and size of trees as well as the type of irrigation system used will determine the amount and the frequency of the irrigation. Sandy soils will for instance require small amounts of water that is applied at short intervals while more clayey soils would require large amounts of water and long interval between irrigations.
In general water application can be 200 L per tree per month for young trees and 1500 L per tree per month for mature trees. However, the amount of rain should be taken into consideration, especially in the summer rainfall regions.</td></tr>
<tr><td>HARVESTING</td><td>The trees should not be allowed to bear fruit during the first 3 years after planting as it will stunt it's growth. Trees should only be allowed to bear fruit in the 4th year after planting.</td></tr>
</table>

	The colour, texture, aroma, taste, shape and size of fruit are judged by looking, touching, smelling and tasting the fruit. Fruit can be bruised or injured quite easily during harvesting and transport. It is therefore important to handle the fruit with care. The first step is to clean the harvesting containers with soap and water. This will ensure that the fungal spores that cause decay, are killed. The nails of the picker should be short in order to prevent marks on the fruit. It is always better to harvest fruit early in the morning when it is cool. The harvested fruit should be taken out of the sun and kept in the shade until it is transported to a cold storage facility.Thehe harvested fruit should be packed in a single layer so that they do not touch each other.
STORAGE	The fruit should be transported to a cold storage facility. The fruit must be kept in cold storage to maintain fruit quality and shelf-life. Only healthy fruit should be placed in a cold room. There is an ideal storage temperature for every kind of fruit. The optimum storage temperature for peaches and nectarines is – 0.5°C.
YIELD	A yield of between 11 and 20 kg per tree can be obtained.
CROP MANAGEMENT	Pruning is usually done when the trees are dormant, i.e. from the middle of July until the end of August.Pruning starts directly after planting when the tree is cut down to knee-height. This step is important as it will ensure that the fruit bearing branches develop low on the stem of the tree and therefore aiding the harvesting process once the tree come into bearing. Pruning to shape the tree is done during the first two years after planting while corrective pruning should be done during the third year after planting and every year thereafter. Water shoots should be removed during the summer and dead and diseased branches removed throughout the year. Fruit thinning is also very important in obtaining fruit with a acceptable size and to preventthe tree to produce a too large a crop. If the crop is too large, it could result in poor growth the next season. Fruit thinning is done just before the pith inside the fruit starts to harden and when the fruit is about the size of a 20c coin. If fruit thinning is done after this stage, it will have no effect on the size of the fruit. A rule of thumb for thinning is to leave a space the length of a pruning shears between one to two fruit. Another way is to leave a space the width of a hand, between each fruit. Organic or inorganic mulches could be applied on the soil surface as it will help to control weeds and conserve soil moisture.
PESTS	There are a number of pests that can occur on peaches trees. However, the ones most often encountered are fruit fly, fruit-piercing moth, vinegar fly, codling moth, false codling moth, oriental fruit moth, American bollworm, aphids, pernicious scale and red spider mite.
DISEASES	The following diseases can occur, namely , brown rot, leaf curl, scab, powdery mildew, *Phytophtora* root rot, soft rot/blue mould, bacterial cankers and bacterial spot.

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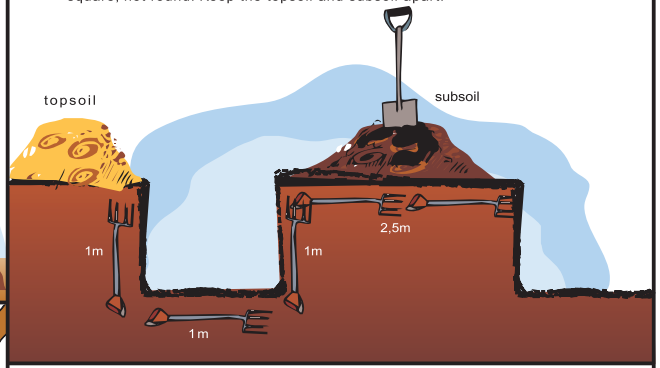
LET'S GROW PEACHES

	J	F	M	A	M	J	J	A	S	O	N	D
PLANTING							×	×				
SUMMER PRUNING	×										×	×
WINTER PRUNING						×	×					
PESTICIDE SPRAYING	Only when necessary											
FERTILISATION	×	×	×						×	×	×	×
HARVESTING	×	×									×	×

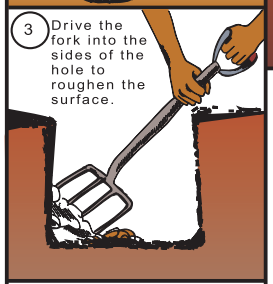
REMEMBER: Order your fruit trees from the nursery a year in advance!
Ask professional help in selecting the fruit kind as well as the cultivar suitable for your area.

1 Take a soil sample and have it analysed to know how much fertiliser is needed.

2 Prepare the planting holes. (1 meter wide, 1 meter in length and 1 meter deep). Make the different planting holes 2,5 meters apart. Make the holes square, not round. Keep the topsoil and subsoil apart.

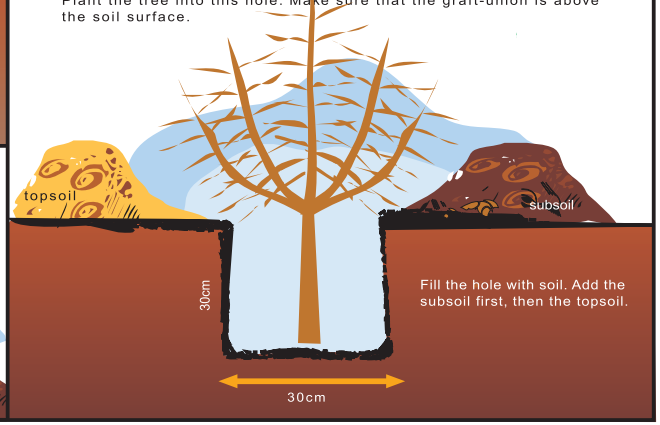


3 Drive the fork into the sides of the hole to roughen the surface.

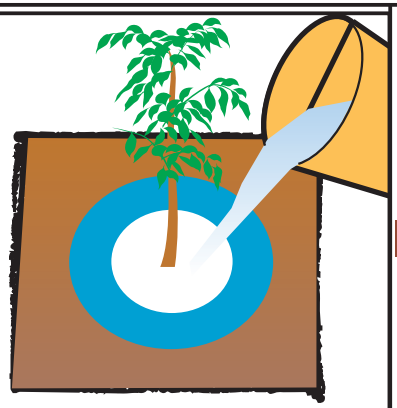


4 General fertiliser:
1 handful bone meal + 1 bucket (5litres) compost
OR 1 matchbox Superphosphate + 1 bucket (5L) compost.

5 Make a square hole in the middle of the holes which you have prepared previously (30cm wide X 30cm length and 30cm deep). Roughen the edges with a fork. Keep the topsoil and subsoil apart.
Plant the tree into this hole. Make sure that the graft-union is above the soil surface.

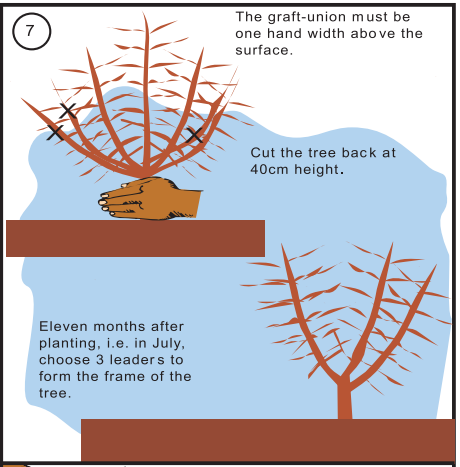


6

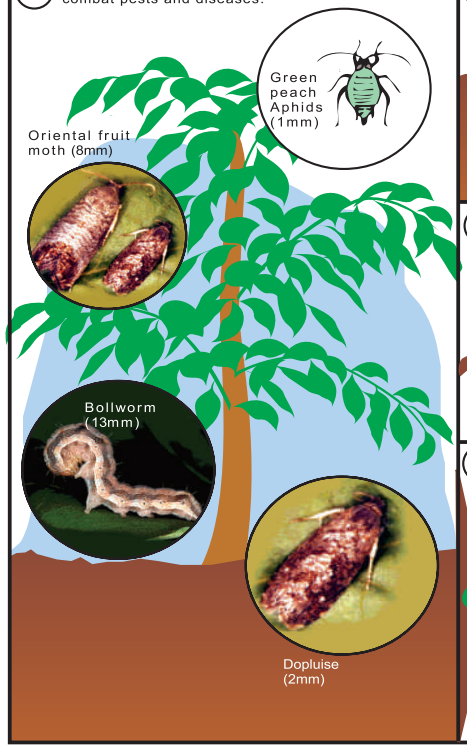


Form a basin around the tree and add 10 litres of water after planting, then 20 litres per month.

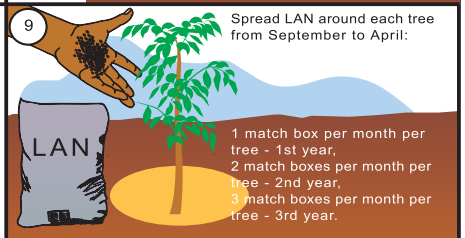
7 The graft-union must be one hand width above the surface.



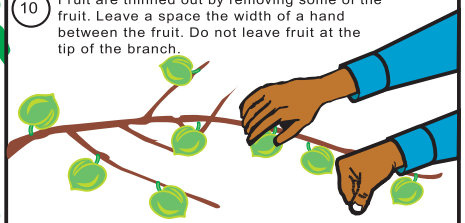
8 Visit your trees weekly, scout for insects and combat pests and diseases.



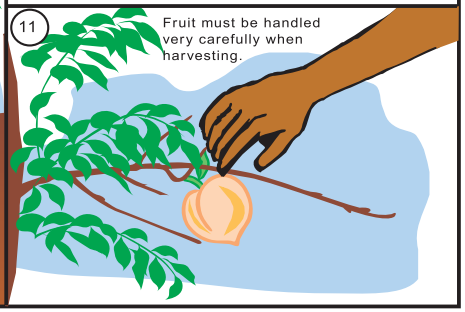
9 Spread LAN around each tree from September to April:



10 Fruit are thinned out by removing some of the fruit. Leave a space the width of a hand between the fruit. Do not leave fruit at the tip of the branch.



11 Fruit must be handled very carefully when harvesting.



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APRICOT

Apricots (*Prunus armeniaca*) originated inChina but were introduced to South Africa by Jan van Riebeeck during the 17th Century. A possible descendent from these trees, the so-called 'CapeApricot' was the most important apricot type that was cultivated in South Africa prior to the 1900's. Cultivars such as Royal and Bulida were respectively introduced during 1900 and the late 1930's. Charisma, which was released in 2005, heralded a new era for apricots dueto its attractive, red blushed skin colour. Apricots are rich in vitamin A and minerals such as potassium, iron and copper.

Local names:

Sesotho : Apolokose **Sepedi:** Apolokosi **Sesotho** Apolokosi **IsiNdebele:** Arothi
isiXhosa: Laprikhothi **Tshivenda:** Apricot **isiZulu:** Apricot **Swati:** Laplikhothi
Xitsonga: Apricot

SOIL	Apricots prefer fertile, well-drained, well-prepared soils with a potential root depth of at least 600 mm. Sandy, acidic soils should be avoided. The soil type will determine the rootstock that should be used. Marianna rootstock can be planted on more shallow soils and lime-rich soils of the Little Karoo, while peach rootstock would be more suitable for cultivars such as Royal. Nemaguard would be more suitable for well-drained soils with a low clay content. Soils that show signs of periodic or permanent wetness should be drained. It is important to obtain expert advice on the specific soil-rootstock-cultivar combinations.
CLIMATE	Although apricot trees grow very well in temperate zones, they thrive best in areas with cold, dry winters and dry, hot summers. Areas prone to heavy frost and low-lying areas should be avoided. Most of the cultivars are prone to crack under high humidity conditions. Heavy rainfall during the subsequent period will promote the occurrence of blossom blight. Some of the cultivars are prone to delayed foliation. The specific number of cold units of a specific area will determine the suitability of a specific cultivar.
CULTIVARS	Most of the more recent cultivars in South Africa have Plant Breeders Rights and are therefore protected by legislation against illegal propagation. However, there are enough old 'open' cultivars such as Peeka, Palsteyn and Royal that can be purchased. It is also important to keep in mind that some of these open cultivars might not be suitable for certain areas. In order to ensure that the trees are true-to-type and disease-free, one should purchase the trees from a respectable, registered nursery.
PLANTING TIME	The best time to plant is when the trees are still dormant, i.e. late July to mid August.

PLANTING METHODS	There are certain aspects which should be taken into account before the trees are established, namely: slope, planting density and planting depth. 1. **Slope** Cold pockets, in low-lying areas such as the bottom of a valley should be avoided as the cold air will accumulate in the lower-lying areas which could lead to frost damage. It is always best to plant the trees on the northern slope and to orientate the tree-rows in a North-South direction. **2. Plant density** Apricot trees normally have a life span of 15 to 20 years. It is therefore important not to plant the trees too close to each other. Apricot trees are normally planted 2.5 m apart within the planting row and at a spacing of 4 to 5 m between the planting rows. However, the planting density will depend on the existing irrigation system and size of the implements that would be used, such as tractor and spraying equipment. Plant density also depends on the properties of the selected rootstock and the training system which will be used. The growth habit, i.e. upright or spreading, will also determine the plant spacing. **3. Plant depth** Nurseries usually sell open-rooted trees in bundles of 20 to 25 trees. The roots should be covered with moist wood chippings when it is transported from the nursery to the farm. This step is essential to prevent the roots from drying out. The planting holes should be made to the same depth as they have been in the nursery, provided the soil was prepared properly in advance. However, if the soils have not been prepared in advance, i.e. house gardens, it would be necessary to make larger square planting holes: 1 m x 1 m x 800 mm deep. The walls of the planting holes should be roughened in order for the plant roots to penetrate the soil adjoining the planting hole. Specific amounts of lime, phosphorous, potassium and micro-elements, based on the soil analysis, should be applied to the soil and mixed thoroughly. The roots should not get into contact with any fertilizer or manure which was applied into the planting hole as the roots might get scorched. The trees should be planted with the bud-union of the tree approximately 5 to 10 cm above the soil surface. The soil should then be packed firmly around the roots and irrigated directly after planting. Care should be taken not to compact the soil in the planting hole as it would have a negative effect on the soil aeration which will in turn result in poor root development. The central, leading branch of the tree must be trimmed directly after planting to approximately 20 to 30 cm above the graft-union (±70 cm above the soil surface). Depending on the training system, the tree should be allowed to develop 3 to 4 well-positioned branches which will eventually form the main scaffolds.
FERTILIZATION	The nutrient status of the soil as well as of the trees can only be determined by analyzing the soil and leaves and the fertilization program should therefore be based on the results of the soil analysis. Factors such as the removal of the soil's nutrients by the crop, effective application of fertilizers to the soil and fertilizing according to the expected production, should be taken into consideration. Soil samples should therefore be taken prior to soil preparation and every three years after planting. Leaf samples on the other hand should be taken annually during January. Phosphorous are applied during soil preparation. Specific amounts of lime, phosphorous, potassium and micro-elements, based on the soil analysis, should be applied to the soil and mixed thoroughly. However, as a rule of thumb one handful of bonemeal plus

<table>
<tr><td></td><td>one bucket full (5 liter size) of compost OR one matchbox of Superphosphate plus one bucket full of compost can be applied preplant. A general guide for the application of fertilizers thereafter, are indicated in the Table below.
<table>
<tr><th>Tree age (year)</th><th>Amount of nitrogen (gram/tree/month)</th></tr>
<tr><td>1</td><td>30</td></tr>
<tr><td>2</td><td>60</td></tr>
<tr><td>3</td><td>90</td></tr>
<tr><td>4+</td><td>Amount must be determined by the results of the soil and leaf analysis.</td></tr>
</table>
Fertilizers are quite expensive and some of them such as nitrogen leach readily from soils. It is therefore of the utmost importance to seek expert advice in order to ensure that the fertilizers are applied in the correct way and that the correct amounts of fertilizer are applied.</td></tr>
<tr><td>IRRIGATION</td><td>The soil type, the quality, availability and accessibility of water, the climatic conditions, the age and size of trees as well as the type of irrigation system used will determine the amount and the frequency of the irrigation. Sandy soils will for instance require small amounts of water that is applied at short intervals while more clayey soils would require large amounts of water and a longer interval between irrigations. Post-harvest irrigation is important as the next season’s fruit buds are formed during the post-harvest period. Although the trees are dormant during the winter months, they will still need water. Trees in the summer rainfall areas should therefore be irrigated at least once a month during the winter.
In general water application can be 200 L per tree per month for young trees and 1500 L per tree per month for mature trees. However, the amount of rain should be taken into consideration, especially in the summer rainfall regions.</td></tr>
<tr><td>HARVESTING</td><td>The trees should not be allowed to bear fruit during the first 3 years after planting as it will stunt it's growth. Trees should only be allowed to bear fruit in the 4th year after planting.
The fruit should be harvested at the right stage in order to ensure a long storage and shelf-life. Apricots that are too ripe when picked are more susceptible to internal breakdown. However, harvesting maturity is not so critical if fruit is harvested for home-use and it can be picked at a riper stage. The colour, texture, aroma, taste, shape and size of fruit are judged by looking, touching, smelling and tasting the fruit. Riper fruit are more prone to bruise. Care should be taken not to bruise the fruit as the bruise marks will not only make the fruit unacceptable to the consumer, but it will also act as entry point for fungi that will spoil the fruit.</td></tr>
<tr><td>STORAGE</td><td>Care should be taken in transporting the fruit to suitable cold storage facilities. Damage can be caused if the fruit is not stored at the correct temperature. The fruit will freeze when the temperature is too low or ripen too rapidly when the temperature in the cold room is too high. The optimum storage temperature for apricots is – 0.5 ^{o}C.</td></tr>
<tr><td>YIELD</td><td>A yield of between 11 and 20 kg per tree can be obtained.</td></tr>
<tr><td>CROP MANAGEMENT</td><td>Pruning starts directly after planting when the tree is cut down to knee height. This step is important as it will ensure that the fruit bearing branches develop low on the stem of the tree and therefore aiding the</td></tr>
</table>

	harvesting process once the tree comes into bearing. Pruning to shape the tree is done during the first two years after planting while corrective pruning should be done during the third year after planting and every year thereafter. Water shoots should be removed during the summer and dead and diseased branches removed throughout the year. Apricots can be pruned during the winter in order to stimulate the development of new shoots. A shoot bud will develop during the first season after pruning and will give rise to a shoot (branch). During the second season, buds will develop on this shoot. These buds will develop into flowers. There are two major systems used to prune-free standing trees, namely the central leading branch and the vase system which has three leading branches. The main purpose of both these systems is to allow enough sunlight to penetrate and reach all parts of the tree. Sunlight is very important for the development of branches (shoots, vegetative) and flower (reproductive) buds. Without sunlight, the branches will stop growing, die-back will occur and no flower buds will be produced. Apricot trees producing fruit on spurs and should be thinned to one fruit per spur. However, this can differ for each cultivar and the local climate and conditions in the orchard.
PEST	There are various pests which can occur on apricot trees. However, the ones most often encountered are fruit fly, fruit-piercing moth, vinegar fly, codling moth, false codling moth, oriental fruit moth, American bollworm, aphids, pernicious scale and red spider mite.
DISEASES	The following diseases can occur, namely , brown rot, leaf curl, scab, powdery mildew, *Phytophtora* root rot, soft rot/blue mould, bacterial cankers and bacterial spot.

FIG

The domesticated types of fig (*Ficus sp.*) were introduced to South Africa during the late 17th Century. South Africa is blessed with several types of indigenous fig trees. The fig producing industry is relatively small and mainly situated on fruit farms within the Western Cape Province of South Africa. However, fig production has the potential to expand.

Local names:

Sesotho: Feiee **Sepedi:** Lego **Setswana:** Feiyi **IsiNdebele:** Ikhiwane / Ifeyi
isiXhosa: Ifiya **Tshivenda:** Mbuyu **isiZulu:** Idolofiya **Xitsonga:** Kuwa

SOIL	Grow well on a wide variety of soil types, ranging from sandy to clay-loamy. A soil depth of at least 1.2 m is required. The soil pH should range between 6.5 and 8.5. They are tolerant to saline soils but very susceptible to nematode infections. Fig trees are able to tolerate high levels of calcium in the soil but are sensitive to sodium and boron.
CLIMATE	Fig trees have low winter chilling requirements, ranging between (150 and 300 units). They are adapted to a wide range of climatic regions and can tolerate relative cold winter temperatures. Warm, dry summers are necessary to produce quality fruit. High humidity during harvest will cause fruit cracking, resulting in vinegary and rotten fruit. The trees can tolerate severe windy conditions but young branches might be snapped by strong winds. Commercial fig production is located in a small niche area, particularly in the Klein Karoo (such as Prince Albert.
CULTIVARS	White Genoa and Kadota are the two most popular cultivars as the fruit can be either be consumed fresh or processed. The first harvest of the White Genoa cultivar is usually utilised in green fig preserves. The Adam's fig requires a dry summer and the fruit is usually not processed. Calimyrna is a multi-purpose tree but it would require the cultivar Capri as a cross-pollinator.
PLANTING TIME	The best time to plant fig trees is when trees are in a resting phase, which is late July to mid August.
PLANTING METHODS	Nurseries usually sell either open-rooted trees or trees planted in plastic bags. The open roots should be covered with moist wood chippings during transportation from the nursery to the farm. This step is essential to prevent the roots from drying out. The planting holes should be made to the same depth as they have been in the nursery, provided the soil was prepared properly in advance. However, if the soils have not been prepared in advance, i.e. house gardens, it would be necessary to make larger square planting holes: 1 m x 1 m x 80 cm in deep. The walls of the planting holes

<table>
<tr><td></td><td>should be roughened in order for the plant roots to penetrate the soil adjoining the planting hole. Specific amounts of lime, phosphorous, potassium and micro-elements, based on the soil analysis, should be applied to the soil and mixed thoroughly. The roots should not come into contact with any fertiliz er or manure which was applied into the planting hole as the roots might get scorched. The soil should then be packed firmly around the roots and irrigated directly after planting. Care should be taken not to compact the soil in the planting hole as it would have a negative effect on the soil aeration which will in turn result in poor root development. The trees should be planted with the craft-union of the tree approximately 50 to 100 mm above the soil surface. Directly after planting, the central leading branch of the tree should be cut to approximately 200 to 300 mm above the graft-union (±70 cm above the soil surface).</td></tr>
<tr><td>PLANTING DENSITY</td><td>Fig trees normally have a life-span of more than 20 years. It is therefore important not to plant the trees too close to each other. They are normally planted 3.0 m apart within the planting row and at a spacing of 5 m between the planting rows, resulting in 666 trees per hectare.</td></tr>
<tr><td>FERTILIZATION</td><td>Specific amounts of lime, phosphorous, potassium and micro-elements, based on the soil analysis, should be applied to the soil and mixed thoroughly. The roots should not come into contact with any fertilizer or manure which was applied into the planting hole as the roots might get scorched.
Fertilizer requirements (gram per tree):

<table>
<tr><td rowspan="2">Age of tree (years)</td><td colspan="2">At bud break</td><td>End of November</td><td colspan="2">Post-harvest</td></tr>
<tr><td>Nitrogen</td><td>Potassium</td><td>Nitrogen</td><td>Potassium</td><td>Nitrogen</td></tr>
<tr><td>1</td><td>60</td><td>100</td><td>60</td><td>100</td><td>60</td></tr>
<tr><td>2</td><td>120</td><td>200</td><td>120</td><td>200</td><td>120</td></tr>
<tr><td>3</td><td>160</td><td>260</td><td>140</td><td>260</td><td>160</td></tr>
<tr><td>4</td><td>200</td><td>320</td><td>160</td><td>320</td><td>200</td></tr>
<tr><td>5</td><td>220</td><td>360</td><td>200</td><td>360</td><td>220</td></tr>
<tr><td>6+</td><td>260</td><td>400</td><td>220</td><td>400</td><td>260</td></tr>
</table>
</td></tr>
<tr><td>IRRIGATION</td><td>Certain important factors should be taken into consideration in deciding on the amount and frequency of irrigation of fig trees. Such factors include soil type, water quality, climate, season, type of fruit, the age and size of trees, growth phase of the tree, the type of irrigation system used as well as mulching with organic material such as straw. Sandy soils consist of coarse particles, resulting in low water holding capacities. It is therefore essential to apply small amounts of water at relatively short intervals. Clay soils consist of finer particles resulting in higher water holding capacities. Larger amounts of water should therefore be applied with longer intervals between irrigations.
In general water application can be 200 L per tree per month for young trees and mature trees would need as much as 100 L per tree per day in peak season in very dry, arid regions without summer rainfall. However, the amount of rain should be taken into consideration, especially in the summer rainfall regions.</td></tr>
</table>

HARVESTING	Trees should only be allowed to bear fruit in the 3rd year after planting. The main harvest is during February. However, some cultivars produce green figs which are harvested during October. Harvesting is one of the most menacing factors in the cultivation of figs. The rubbery latex is highly irritant and an occupational hazard to fig harvesters as well as packers, necessitating the use of gloves for picking and packing. The fruit is primarily marketed in dried or otherwise processed forms.
STORAGE	Ripe figs do not transport well and, once harvested, have very short storage life. It is thus a rarity to find fresh figs in shops and supermarkets. Processed figs (dried, jams or leathers) can fetch high prices in fruit stalls and roadside food stalls.
CROP MANAGEMENT	There are two pruning phases in the life of a fig tree namely the training and maintenance phases. During the first phase the tree are trained and shaped to form a strong framework. A strong and healthy frame will enable the tree to bear fruit for many years to come. During the second phase, when the trees are mature, the trees are pruned to stimulate growth of fruit bearing branches. Overgrown and dead branches are also pruned away during this phase. Heavy winter pruning should be avoided. It is advisable to prune immediately after the main crop is harvested or to prune during summer.
PEST	Problems with the following pests can be experienced, namely, red spider mite, fruit fly, nematodes, and scale insects.
DISEASES	Mosaic virus and brown rust can infect fig.

8. POST-HARVEST HANDLING AND PRESERVATION

The post-harvest handling of freshly produced fruit and vegetable is important to keep them fresh until they are cooked and consumed. Always follow basic hygiene practices when working with fruit and vegetables.

8.1 Hygiene

Basic hygiene practices should be strictly adhered to because they are extremely important in ensuring food safety. If hygiene practices are not followed this can lead to the spread of diseases and furthermore the bacteria that are presenin food can cause food decay and poisoning. It is essential to work hygienically when preparing or preserving food. More information is available in Part 6 of Nutrition Education Guidelines Volume 1: NSNP Educators.

Practicing good hygiene during preparation and preservation starts with personal cleanliness and includes cleanliness of the raw and processed vegetables as well as whole working environment. People carry bacteria on their hands, clothes, hair and under their nails. These bacteria spread to other people by touching them, sneezing, coughing, and handling food. This can be prevented by washing hands before preparing food , washing vegetables thoroughly and by cooking our food properly. Preservation is one way to slow down food spoilage and it is crucial thata hygienic method is applied and the working place and tools are kept clean.

Basic hygiene tips

- Maintain good personal hygiene:
  - ✓ Wash hands before handling vegetables.
  - ✓ Dry your hands with a clean towel –a dirty towel will be contaminating your hands again.
  - ✓ Keep finger nails short and clean.
  - ✓ Tie hair back or cover it.
  - ✓ Cover wounds on hands with water proof plasters.
- Inspect containers and remove rotten vegetables/fruits as soon as it is received.
- Clean up properly after each day's work.
- Work on a surface that can be cleaned easily, e.g. stainless steel.
- Work in places which do not have a lot of flies or put insect screens in front of the windows

8.2 Storage

It is advisable to harvest vegetables and pick fruit just before they are needed for cooking or consumption. Fresh produce can, however, be stored for hours (even days) before they are used. Fruits and vegetables generally need refrigeration to keep fresh.

Storage of vegetables

- Perishable vegetables (e.g. leafy vegetables, bean). must be used shortly after harvest or kept refrigerated.
- Medium perishable vegetables (e.g. cabbage, beetroot, carrot, tomato, green mealies).can be kept 1-2 days at room temperature, preferably in a refrigerator
- Medium storage life vegetables (e.g. sweet potato, potato, pumpkin or butternut)can be stored in a cool dry place for up to 1-2 months.
- Long storage life vegetables (e.g. amadumbi, onion).can be stored in a cool dry place for up to 6 months

Storage of fruits:

- Perishable fruit(e.g. fig, papaya, peach, apricot) can be kept for 1-2 days at room temperature; preferably in a refrigerator
- Medium perishable fruits (e.g. apple, mango, granadilla, citrus) can be kept for 3-5 days at room temperature, preferably stored in a refrigerator - except for bananas.

8.3 Preservation

The purpose of preserving fruits and vegetables is to have them available throughout the year. Drying, salting, fermentation and bottling/canning of agricultural products have provided long term food security.

8.3.1 Bottling/Canning of vegetables

Canned vegetables can be used in soup, stews, to make sauces or as a vegetable dish and are convenient and easy to use and store. There are two different canning methods.

The first method is the **boiling water canning** method, where vegetables are sterilized in a big pot with boiling water at temperatures of 95 to 100^0C. To safely use this method vegetables need to be pickled or vinegar added to them when bottled. This method is a less expensive to start with, because you only need a big aluminum pot and it is safe to make pickles, chutney, sauces and jam.

The second method is the **steam pressure canning** In this method a pressure cooker is required and water is heated to temperatures above 100^0C. By using the steam pressure canning method we can safely can all types of vegetables and fruit but a pressure cooker and special canning jars, which are expensive, are required.

(a) Canned/bottled tomato

Canned tomatoes can be used in meat and vegetables stews for flavour and can also be sold.

Step 1: Pick and select tomatoes
Ripe tomatoes are used to make tomato sauce, pureed tomato and tomato jam. Green tomatoes are used to make chutney. Handle ripe tomatoes with care to prevent bruising, especially if you are not going to process them immediately.

Step 2: Prepare tomatoes
Wash the tomatoes properly. Rinse them and allow excess water to drip off. Cut out the hard, white tissue around the core as well as green and rotten pieces. Bruised parts must be removed because they will give a bad taste or form lumps in the processed product.

TOMATO KETCHUP

You need

12 ripe tomatoes
2 onions
2 cups (500 ml) vinegar
3 table spoons sugar
1 table spoon salt
2 teaspoons cloves
2 teaspoons cinnamon
2 teaspoons all spice
2 teaspoons nutmeg
½ teaspoon cayenne pepper

Method

a. Chop tomatoes and onions finely.
b. Bring to the boil and stir regularly.
c. Cook until the tomato and onion are soft.
d. Strain the mixture through a sieve or course muslin.
e. Return the puree to the pot and add the rest of the ingredients.
f. Cook slowly for 2 - 3 hours or until the mix is thick. Remember that the ketchup will be thicker when it is cold, so do not boil for too long.
g. Pour the ketchup into sterilized bottles and seal immediately.

Once you have experimented with the cooking time, you can make ketchup to you taste and use bigger quantities. Remember to make notes while you are experimenting.

CRUSHED CANNED TOMATO

You need

Fully ripe (RED) tomatoes
Salta large

Method

1. Dip tomatoes in boiling water for about 2-3 minutes until the shins burst (blanching).
2. Remove and dip in cold water for 1 minute. Stand to cool and remove skins as soon as tomatoes are cool enough to handle.
3. Take a quarter of the tomatoes and heat in pot that is big enough for all the tomatoes.
4. Crush the tomatoes with a wooden spoon to make juice. Add the rest of the tomatoes, heat, stir and bring to boil for 5 minutes.
5. Fill clean jars with hot tomatoes and leave 1cm space at the top.
6. Add 1 teaspoon of lemon juice to every 600ml bottle or 1 teaspoon to every 1.2 liter bottle.
7. Screw the lids of the bottles on securely - not too tight or too loose. Place bottles on a wire or wooden rack in a big pot and cover with hot water for about 2cm
8. Bring the water in the pot to the boil and put the lid on.
9. If small bottles are used (600 ml), boil for 45 minutes and if large bottles are used, boil for 55 minutes.
10. Check every now and then that the bottles are covered with water. Add **boiling** water if the level becomes low.
11. Remove jars from boiler and allow to cool. If the lids were screwed on correctly, a vacuum will be formed between the tomatoes and the lid.
12. The next day, check to see if the lids are tight. If they are loose, use the tomato within a few days.
13. If the lid makes a bulge it was screwed on too tight. Use within a few days.

Sterilize canning bottles before use.

Never use canned tomatoes if the product is showing signs of being spoilt.

Start with small amounts of tomatoes. When you feel confident, increase the amount slowly.

8.3.2 Freezing

The Beans, carrots, pumpkin/butternut and spinach can be frozen with success.

The steps for freezing vegetables

1. Select good quality of vegetables.
2. Wash and cut into slices.
4. Blanch – place in boiling water for 3 minutes 5. Cool shortly after cooking and drain most of the water.

8.3.3 Drying

Drying is a preserving method used for fruits and vegetables to ensure availability throughout the year. Dried products take up little storage space and can be stored without electricity for up to six months. When preparing dried vegetable for cooking, soak them first in cold water until soft (half an hour to two hours) and then cook or use it in soups, stews and isishebo.

(a) Drying tomato

Dried tomatoes will be useful in the meals to add flavor or make relish. They do not have to be soaked before adding them to other cooking ingredients.

Step 1: Picking
Only ripe tomatoes should be used. After picking the tomatoes, rotten or green ones must be removed and thrown away.

Step 2: Preparation
Tomatoes can be cut in halves and dried with their skins, or the skin you can be removed to make a puree, which is dried on a plastic or stainless steel sheet. For drying pureed tomato, the fruit are blanched and the skins removed. For drying of tomatoes that have been halved, do not blanch just cut them lengthwise and proceed to Step 6.

Step 3: Blanching
Boil water in a big pot and drop tomatoes in it. Keep tomatoes in boiling water for 2-3 minutes until the skins split. Do not leave them in boiling water for longer than necessary because they will become too soft.

Step 4: Cooling
Remove the tomatoes from boiling water and cool immediately in a container with cold water for 1 minute. The skins are peeled off by hand when the tomatoes are cool enough to handle. Puree the tomatoes using a sieve or potato masher.

Step 5: Drying

Spread the pureed tomatoes, while it is still hot, thinly on a plastic or stainless steel sheet in a thin layer (no thicker than half a centimeter) and place in the sun. For whole dried tomatoes, the halved fruit are spread out on the drying tray in one layer and placed in the sun. Cover the drying vegetables with muslin cloth to keep insects and birds off. After the first day of drying, stir the drying tomatoes (whole tomatoes) twice a day to make sure they dry evenly.

Sun drying of tomatoes takes 2 – 4 days. Pureed tomatoes are dry when they become leathery and can be rolled up without breaking. Whole dry tomatoes are ready when they become hard, but they should be removed from the sun before they are so hard that they break when bent

Step 6: Storage
Dry tomatoes are stored in air and watertight containers. Store the containers in a dry and cool place. If you use a cloth or plastic bags you must keep insects and rats out of the storage room. Check the containers of dry tomatoes regularly to see if they are still in a good condition.

(b) Fruits suitable for drying

Examples of fruit that can be dried are mango, banana, pawpaw, apple, pine apple, guava, litchi, peach and grapes.

Below the procedure for drying mango is presented as an example.

Green Mangoes ready for sorting

Washing of Mangoes

Peeled Mangoes

Sliced Mangoes

Slices dipped into sodium solution

Trolley full of Mango slices

Electric dryer

Packed dried mangoes

For more information, contact:ARC- Institute for Tropical and Subtropical Crops, Nelspruit, 013 753 7000.

8.3.4 Bottling/canning fruit

Fruit are usually canned in a sugar solution or syrup. The most common mix is 1 part sugar in two parts water for fruit such as peach, pear or guava. Acidic fruits such as apricots and berries are canned in mix of 1 part sugar and 1 part water. Ripeness of fruit influences the cooking time. Fruit which tends to discolor are kept in a salt solution till they are cooked. Always sterilize the jars/bottles and lids by immersing and keeping them hot until they are used.

How to can/bottle fruit:

a. Select blemish-free, healthy fruit and wash them.
b. Cut fruit in half/quarters. Peel skin except for soft fruits like apricots.
c. Prepare the syrup/sugar solution.
d. Bring the syrup to boil and add fruit.
e. Pack fruit into sterilized bottles in overlaying layers with fruit cavity side down.
f. Fill with syrup and remove air bubbles using a knife or any long blunt object.
g. Seal the bottle and store.

8.4 Marketing

The main purpose of preserving fruits and vegetables is to lengthen their shelf life so that they are available for use throughout the year in the school nutrition programme or home. Excess produce and preserved products can also be sold to earn income from which to buy supplies such as seeds and fertilizer for the next planting season.

Tips on marketing the produce:

- Make sure that the crops are sold at market-related prices. Observe what is happening on the commercial or fresh produce markets or local shops.
- The demand of a crop will determine the price. For instance if produce is not available from many gardens, the price will rise. If a type of vegetable is available in all surrounding gardens, the price will drop.
- It is a good marketing plan to harvest when the customers are with you.
- Consider the size of the crops (e.g. cabbage, spinach, beetroot, carrots) and make market-related bundles The size of the bundles is generally about 1 kg.
- Make sure you know what the demand for packaging size is. Do not pack in large bags if people can only afford small packets.
- A proper planting program is required to ensure continuous supply of commodities.
- Everybody is prepared to pay for good quality, so if the crops from your garden are of good quality, customers will pay what you charge.
- If a market demands a certain product, try to deliver the product at the right time and place.
- Be clear on the price in your advertisement. Do not let people come a long way to buy your produce and then the price is so high that no one can afford it.
- Do not try to cater for a market that is far away from you because high transport cost and take up all your profit.

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Glossary

Aeration	This is the process by which air is circulated through plants and is important to control leaf diseases.
Bolting	The untimely production of a seed stalk on crops such as spinach and carrots. This is detrimental for production of leaves in spinach.
Biofumigation	The use of biological active rotation and cover crops for suppressing soil-borne pests and diseases.
Biological control	The process by which an undesirable organism (e.g. causing a plant disease, a insect or weed) is controlled by using a beneficial organism.
Brassicas	The term "*brassica*" covers a large group of plants that include cabbages, radishes, turnips, cauliflower, canola, rape and kale.
Broadcast	Apply fertilizer by spreading or scattering it over the soil surface
Budding	a grafting technique in which a single bud from the desired scion is used rather than an entire scion containing many buds. It is most commonly used for the propagation of fruit trees like citrus
Chemical control	Apply chemicals to control pests and diseases
Crop rotation	A system of crop production in which the various crops are grown in succession on the same piece of land and in a certain sequence, in such a way so that that no crop is planted on the same piece of land for more than once in three years.
Cucurbits	Pumpkins, squash, marrow, cucumbers, watermelons, muskmelons are members of the vine crop family called cucurbitaceae (commonly known as cucurbits).
Cultivar	A cultivar is a cultivated variety of a plant that has been deliberately selected for its desirable characteristics
Cure	Preparing crops for storage by drying. Results in extended storage life e.g. of butternut/pumpkin fruit and sweet potatoes.
Deficiency	Lack of nutrients such as nitrogen or potassium in the soil. Leaves normally show specific deficiency symptoms related to the deficit nutrients.
Dioecious	Refers to a plant population having separate male and female plants such as the papaya.
Emergence	Seed germinate in soil or growth medium leading to the emergence of the seedlings

Fertigation	To fertilize and irrigate at the same time, by adding water soluble fertilizers to the irrigation water
Fertilization	Application of substances which supply plant nutrients or amend soil fertility.
Fertilization	Apply fertilizer to the soil
Fallow	Fallow land is cultivated land that is not planted for a season; it may or may not be plowed. The land may be cultivated or chemically treated for control of weeds and other pests or may be left unaltered. Allowing land to lie fallow serves to accumulate moisture in dry regions.
Foliage	The leaves of a plant.
Fungicide	Chemical compounds or biological organisms used to kill or inhibit fungi or fungal spores. Fungi can cause serious damage in agriculture, resulting in critical losses of yield, quality and profit.
Germination	The process in which a plant or fungus emerges from a seed or spore and begins growth. The most common example of germination is the sprouting of a seedling from a seed
Grafting	Method of asexual plant propagation widely used in agriculture and horticulture where the tissues of one plant are encouraged to fuse with those of another. It is most commonly used for the propagation of fruit trees like avocados and mangos.
Gravel film technique,	A hydroponic technique which is a variation of the Nutrient Film Technique (NFT). The principle of NFT systems is that a balanced nutrient solution (salts and trace elements in solution) is made available to the plant root system as a 1 to 2 mm 'film'. This is achieved by flowing the solution down a closed gully filled with a 4cm layer of gravel to shade the root system and support the plant.
Green manure	Crop (e.g. legumes) produced for incorporating into the soil to improve the nutrient content of the soil.
Growth medium	Medium used to grow plants in containers or seedling trays. Due to the relatively shallow depth and limited volume of a container, growing media must be amended to provide the appropriate physical and chemical properties necessary for plant growth. Field soils are generally unsatisfactory for the production of plants in containers. This is primarily because soils do not provide the aeration, drainage and water holding capacity required.
Herbicide	A herbicide, commonly known as a weed killer, is a chemical used to kill unwanted plants.

Hermaphrodite flower	Papaya plants occur in one of three sexual forms: *male*, *female*, or *hermaphrodite*. *Hermaphrodite* flowers have both an ovary and stamens bearing pollen. They can pollinate themselves and do not require the presence nearby of another plant.
Hydroponics	Soilless culture. A crop production system where plants are grown in an artificial medium other than natural soil. All the nutrients are dissolved in the irrigation water and supplied on a regular basis to plants.
Integrated pest management	Sustainable control of pests and diseases, by combining alternative methods of control in a way that minimizes the use of chemical pesticides.
Legumes	Plants belonging to the family Fabaceae (e.g. beans, peas, cowpeas, pigeon peas, bambara groundnuts).which carries pods that splits into two valves with the seeds attached to one edge of the valves. Legume plants are notable for their ability to fix atmospheric nitrogen.
Lodging	Leaves fall over as bulbs matures e.g. in onions.
Liquid fertilizer	Liquid fertilizer is just a solution of water-soluble fertilizers.
Macro-nutrients	Nutrients required in large amounts for growth and development of plants.
Micro-nutrients	Nutrients required in small amounts for growth and development of plants.
Mulch	A thick layer (50-150mm) of organic material (e.g. grass or old dry crop material) or synthetic material (e.g. plastic) spread over the otherwise bare soil to reduce erosion, conserve water and reduce weed growth.
Nematodes	Minute roundworms, many species of which are plant parasitic. (Also called eelworms).
Nutrient film technique	A hydroponic technique wherein a very shallow stream of water containing all the dissolved nutrients required for plant growth is recirculated past the bare roots of plants in a watertight gully, also known as channels.
Open-rooted	Trees are not in planted in plastic bags when it is made in the nursery. The trees are supplied open-rooted by the nursery to the farmer. This is the case for peaches and apricots. However, the figs are planted in plastic bags.
Perennial weeds	Weeds with a life cycle of longer than one year.

Pest	Any organism (e.g. some bacteria, insects, fungi, mites, nematodes, rodents) injuring or detrimental to a beneficial plant. Alternatively referred to as pests and diseases.
Pesticides	Any chemical or physical agent that destroys, prevents, repels or attacks pests in order to control pests.
Post-harvest	The stage of crop production immediately following harvest, including cooling, cleaning, sorting and packing.
Provitamin A	Carotenoids, like beta-carotene, that are found in foods of plant origin. Provitamin A is converted to vitamin A in the body.
Ratoon cropping	The second and subsequent crop derived from the suckers. This practice is seen in banana and sugar cane crops. In amaranth ratoon cropping involves several cycles of cutting off the plant during harvesting and allowing them to regrow for the next harvest.
Root stock	Normally a seedling which already has an established, healthy root system, used for grafting a cutting or budding from another plant. The use of rootstocks is most commonly associated with fruiting plants and trees and is the only way to mass propagate many types of plants that do not breed true from seed or are particularly disease susceptible when grown on their own roots.
Root system	The root system of plants consists of shallow roots for taking up nutrients and water, and a main roots which anchor the plant in the soil.
Scion	A detached shoot or twig containing buds from a woody plant used in grafting
Scouting	Monitoring for the presence of pests and pest damage, as well as disease symptoms.
Staggered planting	Small, but regular, plantings are made at intervals during the planting season so as to ensure a continuous supply of the crop.
Storage root	Enlarged root (fleshy and > 15 mm thick) which develop at the underground nodes of sweet potato cuttings.
Subsoil	The soil at a depth of 30-60 cm.
Trace element	Chemical element required by living organisms in minute amounts, Exact needs vary among species, but commonly required plant micronutrients include copper, boron, zinc, manganese, and molybdenum ; sometimes referred to as *micronutrients.*

Top dressing	Dry fertilizer is added on top of the soil next to the plant. Depending on the soil type 1-3 nitrogen top dressings are common practice in vegetable production.
Topsoil	The soil at a depth of 0-30 cm.
Volunteer plants	Plants emerging from the field where a crop was planted the previous season.