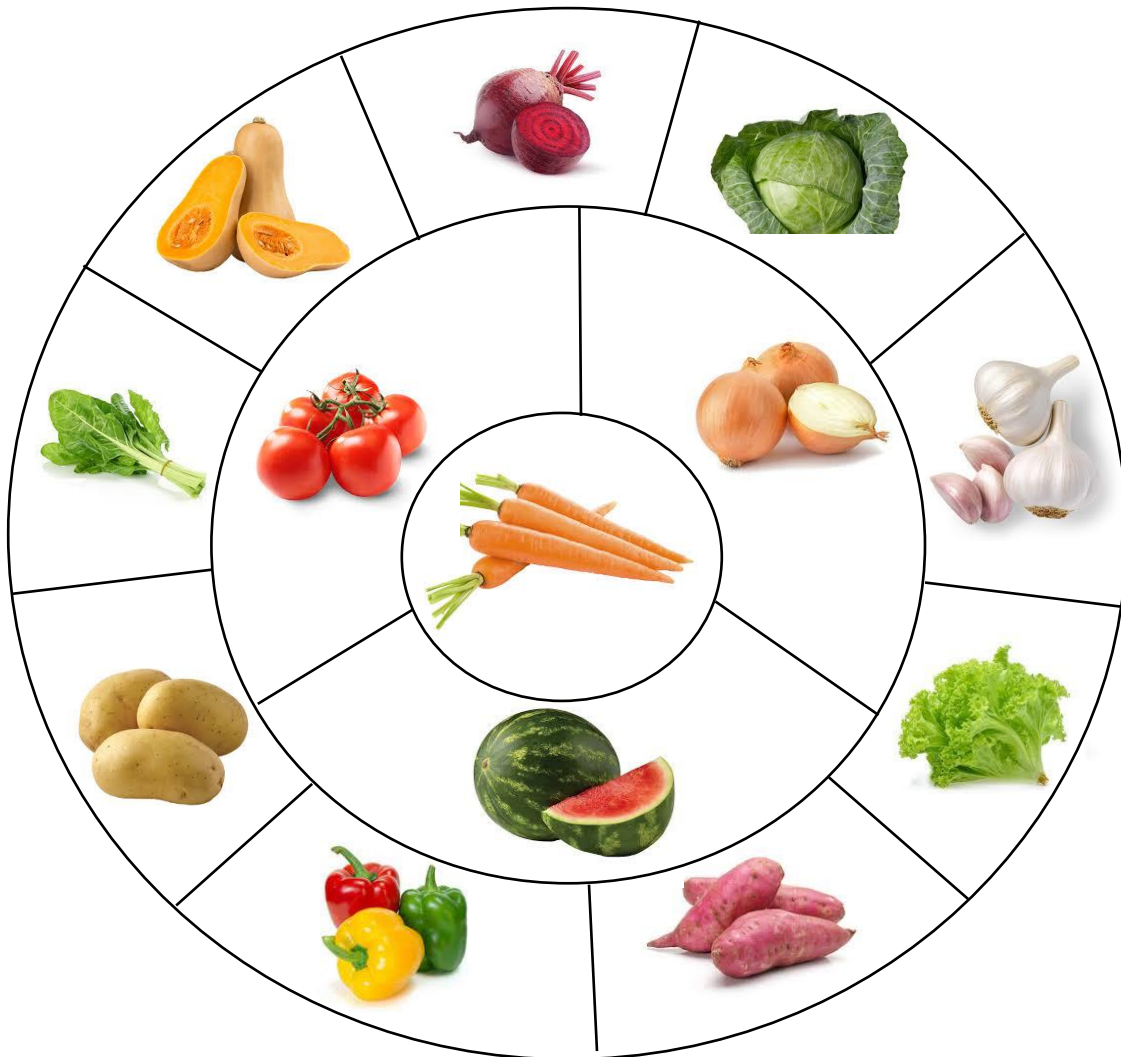




VEGETABLE PRODUCTION GUIDELINES

Information and guide on production of selected conventional vegetable commodities



Production guidelines for conventional vegetables

Published by the Ministry of Agriculture (MoA) in collaboration with ESWADE

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INTRODUCTION

Rising food prices have become a global phenomenon and Eswatini has not been spared from it either. It is a crisis that has gripped even the most developed countries and is raising concern about the effects on the world economy. The constant increases are mainly the result of rising input costs, the exchange rate, competing demands for vegetables and climate change, as well as other factors.

Over the years, the Ministry of Agriculture, her partners and stakeholders has engaged in various initiatives that focus on technology transfer and on meeting the needs of our citizens. The focus lies in the areas of increased agricultural productivity, improved food quality and sustainable agricultural use of natural resources such as water and soil.

The Ministry of Agriculture has been instrumental in the success of horticultural crops, particularly conventional vegetables as commercial products. The Ministry has provided information, knowledge and technical knowhow emanating from research, technological development and technology diffusion to the agricultural sector.

These production guidelines give tips and technical knowhow about the commodity uses, climatic requirements, soil requirements, varieties, planting times, land preparation, planting, fertilization, weed control, pest and disease control, physiological disorders as well as harvesting and handling. This document provides production guidelines for 13 commodities, namely, butternut, cabbage, carrot, garlic, onion, pepper, spinach, sweet potato, tomato, watermelon, beetroot, potato and lettuce.

The Ministry remains committed on its mandate of ensuring household food security and increased sustainable agricultural productivity through diversification and enhancement of commercial agricultural activities. We wish to extend our appreciation to the stakeholders for the support in development of this document.

BEETROOT

1. BACKGROUND INFORMATION

Beetroot (*Beta vulgaris*) is the taproot portion of a beet plant which serves as a storage organ for nutrients. It is one of several cultivated varieties of *Beta vulgaris* grown for their edible taproots and leaves; classified under the *Chenopodiaceae* family. It is used as a food colouring, medicine (as a laxative, a cure for bad breath, coughs, and headaches). Other edible vegetables from the same family as beetroot include all the different types of spinach.

2. CLIMATIC REQUIREMENTS

- ✓ Beetroot is a cool-season crop that is hardy and grows best in spring, autumn and winter.
- ✓ Excessively hot weather causes the appearance of alternating light and dark red concentric circles in the root known as zoning.
- ✓ On the other hand, very cold weather results in slow growth.
- ✓ Optimum growing temperature for beetroot is 15- 20°C with a maximum growing temperature of 35°C.
- ✓ Beetroot germinates best in soil temperatures above 7°C.

3. SOIL REQUIREMENTS

- ✓ The ideal pH for beetroot production is between 5.5 and 6.5.
- ✓ Beetroot prefers deep, well drained, sandy loams to silt loams and high in organic matter.
- ✓ The use of beds is preferable to lower the water table and ensure good drainage.
- ✓ Heavy clay soils or soils which crust after rain or irrigation may cause establishment problems and the production of misshapen roots.
- ✓ Mature beets are fairly tolerant to salinity, whereas seedlings are relatively sensitive.

4. VARIETIES

Globe Dark Red, Red Atlas, Star 1105, Rudolf, Red Ace, Lorrette

5. PLANTING CALENDAR

Area	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Highveld	S	B	B	B	S	S	S	B	B	B	S	S
Middleveld	S	S	B	B	B	S	S	B	S	S	S	S
Lowveld	N	N	B	B	S	S	S	B	S	S	N	N

B – Best planting time, **S** – Suitable planting time, **N** – Not suitable for planting

6. SEEDS/SEEDLINGS

Direct Sowing

- ✓ If you plant seed directly in the ground, soak it overnight in water before planting.
- ✓ Irrigate lightly a day before sowing. When planting in rows, leave at least 30cm between the rows and plant the seeds at least 10cm apart and 3cm deep.
- ✓ Cover the seeds with fine soil and keep the soil moist until the seeds have germinated with the seedlings emerging. ***Use quality seeds with a good germination percentage.***

Seedlings

- ✓ Prepare seedlings 4-6 weeks before the planting date.
- ✓ Use quality seedling which are pest and disease free.
- ✓ Water the field before planting is recommended to keep soil moist.

7. LAND PREPARATION

- ✓ The land should be well prepared by ploughing 15 to 20 cm deep to break up clods.
- ✓ The soil should also be as level as possible, have a good crumb structure and enough moisture, and be free of un-rotted plant material.
- ✓ Add 15 to 25 tons/ha of manure 30 days before planting.

NB: Never use chicken manure which usually affect shelf life.

8. PLANTING/TRANSPLANTING

- ✓ Seed is usually sown in slit trenches 2-3cm deep.
- ✓ Planting in rows is to facilitate the mechanical removal of weeds without disturbing the beet crop.
- ✓ In-row spacing is between 5 and 10cm depending on the size requirement needed at harvest and between row spacing ranges from 20 – 45cm.
- ✓ For early harvest or medium size a planting density of between 250 000 and 300 000 plants per hectare is ideal.

9. FERTILIZER APPLICATION

Basal fertilizer

Option A; 300kg (6 bags of 50kgs) of 2:3:2 (37) kg/ha fertilizer or use 100g of 2:3:2 (37) to every 1m²

Top Dressing fertilizer

Apply a dressing of LAN + KCL when the beetroot at three weeks after emergence to ensure there is enough nitrogen to keep the plants growing well. Apply 100kg/ha (2 bags of 50kgs) LAN + 50kg KCL at a rate of 15g/m² at the three-leaf stage, about three weeks after emergence.

Basal fertilizer

Option B; 300kg (6 bags of 50 kgs) of 2:3:4(30) kg/ha fertilizer or use 100g of 2:3:4 (30) to every 1m²

Top dressing

Apply a dressing of LAN when the beetroot is 4cm to 5cm high to ensure there is enough nitrogen to keep the plants growing well. Apply 200kg/ha (4 bags of 50kg) at a rate of 20g/m² at the three-leaf stage, about three weeks after emergence

NB: It should be noted that these are general recommendations and actual amounts of fertilizers should be based on soil analyses.

11. IRRIGATION

- ✓ Regular light watering is required to maintain soil moisture.
- ✓ Irrigation is important especially in the early stages of plant development and during bulb development.
- ✓ As a guideline 300-350 mm of water is required throughout the growing cycle, an average of 4mm per day.
- ✓ Water requirements is dependent on the season, the variety, and soil type.

12. WEED CONTROL

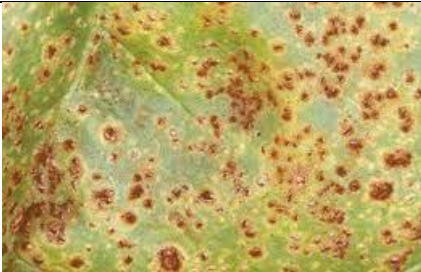
- ✓ Weeds compete with beetroot for space, light, water and nutritional resources in the soil, particularly during the early part of the season.
- ✓ They can reduce yield if left unchecked.
- ✓ Perennial weeds should be eliminated prior to planting beets.
- ✓ Regular cultivating prevents weeds competing with beetroot.
- ✓ Hoe weeding is recommended for small scale producers and selective herbicides are more ideal for control in larger-scale and commercial plantings.

13. PEST AND DISEASE MANAGEMENT

a. Pest Control

Name of pest	What impact does it have on plants	Picture of damage caused by pest	Recommended chemicals	Application rate/20 L water	Withdrawal period
Aphids	They suck juices on lower surface of leaves. If aphids are many, they may result in stunting. Infected leaves are curly and rolled		Decis Cypermethrin, Profenofos Aphicide Plus Malasol	5 ml 20ml 100 ml 15ml 25ml	7 days 7 days 4 days 3 days 2 days
Red spider mite	They suck plant juices on lower surface of leaves.		Abamectin	15 ml	7 days
Millipede	Feeds on roots		Cypermethrin Decis	20 ml 5 ml	7 days 3 days

b. Disease Control

Name of disease	Symptoms	Picture of disease	How can it be it be controlled	How much pesticide should be mixed in 20L of water	Withdrawal period
Leaf spot	Small round brown spots appear on leaves with reddish-purple borders and later turn grey in the center. The tissue in the center falls as the spots become old.		Copper oxychloride Dithane Bravo Ridomil Follow a 2 to 3 year rotation cycle away from beetroot and other related crops	60g 40g 20 ml 50g	3 days 7 days 3 days 7 days
Brown rust	Large numbers of orange or red-brown pustules on leaves.		Copper oxychloride Dithane Amistar	60g 40g 50 ml	3 days 7 days 7 days

14. HARVESTING

Beetroot is normally ready for harvest after 60 to 90 days in summer and 90 to 120 days in winter. Average root size is 5 to 8cm in diameter, with an average yield of 15 to 25 tons/ha. The harvested yield will vary significantly as a result of climate, fertilization, disease infestation and variety planted.

Post- harvest practices

Sorting and grading

All diseased roots and those showing mechanical injury are removed during sorting. Old, dead or damaged leaves should be removed if the crop is to be marketed with tops. Beetroot is graded according to size, from small, medium to large.

2. Packing

Harvested produce should be cleaned with water that contains an anti-bacterial/fungal agent (e.g. spore kill). After washing, beetroot is dried in a cool place that allows air to circulate, away from direct sunlight. It is then packed on plastic bags according to size and shape or on adherence to market specification.

3. Storage

The environment must be dry to avoid fungal attack and kept under shade and the relative humidity at 90 -95 %.

BUTTERNUT

1. BACKGROUND

Butternut (*Cucurbita moschata*) belongs to the cucurbits family (same family with pumpkins, cucumber, marrows, melon and gem squash). They are sensitive to frost and extremely high temperatures. Butternuts are locally used in place of pumpkin and used for processing and prepared foods.

2. CLIMATIC REQUIREMENTS

- ✓ Butternut is a warm-season crop and grows best at temperatures of 23°C to 29°C by day and 18°C to 24°C at night
- ✓ Ideal soil temperature for germination: 20 - 25° C (minimum 16°C)
- ✓ Sensitive to frost and germination is very poor under low temperatures.
- ✓ Temperatures above 29°C cause flower drop

3. SOILS REQUIREMENTS

- ✓ Sandy loams with free drainage and high organic matter content are ideal for butternut production.
- ✓ Poorly drained soils lead to fruit rot
- ✓ The ideal soil depth is 30-40cm
- ✓ Soil pH 5.5 – 6.5

4. VARIETY SELECTION

Butternut should be selected based on market specifications, below are the list of recommended varieties for commercial purposes.

Varieties

Quantum, Shiba, Pilgrim, Waltham, Venus, Barbara, Pluto, Atlas, Frisco, Gilda

N.B. Winter (frost free areas): Pluto, Atlas, Frisco, Waltham

PLANTING TIMES

N.B. While highlighted below is a s a guide, farmers are therefore encouraged to consult with extension officer for ideal planting times.

Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Highveld	B	S	N	N	N	N	N	S	B	B	S	S
Middleveld	S	B	B	S	S	N	S	B	B	S	S	S
Lowveld	N	S	B	B	N	N	S	B	S	N	N	N

B – Best time

S – Suitable time

N – not suitable

5. LAND PREPARATIONS

- ✓ Plough at a depth of 30-40cm and apply recommended dose of lime and manure
- ✓ Harrow to incorporate soil amendments until fine tilth.
- ✓ Form flat ridges and furrows at least 1m apart

6. PLANTING

Plant population guide

- ✓ Ideal spacing: 90 cm by 90 cm (12, 300 plants/ha); 120 cm by 60 cm (13, 800 plants/ha)
- ✓ The ideal plant population should between 11, 000 to 14, 000 plants/ha.
- ✓ Butternuts seeds are planted directly into the soil. Seeds can also be pre-sprouted to reduce rodents damage in the field
- ✓ For an early season crop (spring), seedlings may be used

Furrow planting (for use with furrow irrigation)

- ✓ Make furrows at the recommended row spacing
- ✓ Sow seed on the side of the furrow, just above where the water reaches, at the desired spacing.
- ✓ One seed is sown at each station and gap filling may be applied for non-germinated seed.
- ✓ Plants are trained away from the irrigation furrow as they grow

Ridge/ flatbed planting (for use with drip irrigation)

- ✓ After fertilizer has been incorporated, 40cm wide and 10 - 15cm raised beds are formed.
- ✓ Plant at recommended spacing between plants (plastic mulch may be used to suppress weeds and conserve moisture).
- ✓ Two seeds are sown at each station and thinned to one plant if both emerge (thinned out plant may be transplanted).

7. FERTILIZATION

- ✓ For accurate and most effective use of fertilizers, a soil analysis is needed
- ✓ Kraal manure should be applied at 10 – 15 tons/hectare and worked into the soil 3-4 weeks before planting
- ✓ Basal dressing: 2:3:2 (37) at 300kg to 400kg (6-8 bags) / ha, top dress with LAN at 200kg to 300kg (4-6 bags) / ha and KCl 100kg (2bags) / ha after 30 days/ 4 weeks
OR
- ✓ Basal dressing 2:3:4(39) at 300kg to 400kg (6-8 bags) / ha, top dress with LAN, 200kg to 300kg (4-6 bags) / ha
- ✓ Application of foliar fertilizer (V 12, Multi feed, Nutrient Feed) at 2 weeks intervals to boost crop yield at 750ml to 1,000ml / ha

8. IRRIGATION

- ✓ Water requirements will vary with soil types, season and growth stage
- ✓ Irrigate early in the morning or late in the afternoon (since there are high chances of transpiration)
- ✓ Water requirement critical at planting, vegetative and flowering stages
- ✓ Drip irrigation is recommended for water use efficiency, crop uniformity and reduce foliar disease incidence
- ✓ Other commonly used methods of irrigation include furrow and overhead
- ✓ Reduce irrigation frequency at 4 weeks before harvesting

9. WEED CONTROL

- ✓ The field should be always free from weeds as they compete for nutrients, water and space with planted crops
- ✓ Hand hoeing should be done before vining.
- ✓ Weeds should be controlled by hand pulling at later stages of crop growth.
Paraquat can be used for weed control through usage of a hood attached in the spray nozzle (spraying should be done at 3 to 4 weeks after planting)

10. PESTS AND DISEASE CONTROL

Pest/Disease	Picture of pest/disease	Symptoms	Recommended Chemicals	Application rate on 20 L water	Withdrawal period
Cutworm		Cutting of young plants at the base	- Cypermethrine - Decis forte - Cutworm bait	20ml 5ml	
Leaf miner		Yellow scribbly lines in the leaves	- Agromectin - Makhromecti - Abamectin	12 ml 12 ml 12 ml	7 days 7 days 7 days
Aphids		Clusters of tiny grey/white/green bugs on young leaves, distortion of young shoots, curling of leaves	- Decis - Cypermethrin - Profenofos - Aphicide plus	5 ml 20 ml 100 ml 100 ml	3 days 7 days 4 days 3 days
Fruit fly		Fruits rot while young with visible larvae inside the fruit	- Fruitcare - GF 120 - Mercaptothion - Aviguard	24 ml 700 ml 35 ml 35 ml	10 days 1 day 10 days 1 day
Powdery Mildew		Infected leaves become covered with a white to grey powdery growth	- Bravo - Copper oxychloride - Dithane M45 - Oscar - Amistar opt - Ridomil gold	50 ml 60 ml 40 ml 50 ml 100g 15 ml	3 days 3 days 7 days 7 days 7 days 10 days

Pest/Disease	Picture of pest/disease	Symptoms	Recommended Chemicals	Application rate on 20 L water	Withdrawal period
Downy Mildew		Large, angular or blocky, yellow areas visible on the upper surface	- Funginex, - Bravo, - Copper oxychloride - Dithane M45, - Oscar - Amistar opt	25 ml 50 ml 60 ml 40 ml 50 ml 15 ml	1 day 3 days 3 days 7 days 7 days 10 days
Anthraco nose		Affected leaves have water-soaked lesions which enlarge and later turn brown and the dead tissue may fall out, creating holes in the leaves.	- Bravo, - Copper oxychloride - Dithane M45 - Amistar opt	50 ml 60ml 40 ml	3 days 3 days 7 days
Mossaic Virus		Dark green mosaic, vein clearing, yellowing leaves and hardening. Fruits become mottled and misshaped	- Decis, - Cypermethrine to control the vectors (aphids, thrips) - Remove and destroy affected plants.	5 ml 20 ml	3 days 7 days
Gummy stem / blackrot		Superficial bronzing on the skin with distinct circular patterns	- Avoid irregular irrigation - Copper oxychloride - Dithane M45	60 ml 40 ml 15 ml	3 days 7 days 10 days

11. PHYSIOLOGICAL DISORDERS

Name of physiological disorder	Picture of physiological disorder	Symptom	Prevention or correction measure
Fruit cracking		Cracking or splitting of the shell	Avoid irregular irrigation Proper variety selection Adhere to recommended planting times

12. HARVESTING AND HANDLING

- ✓ Harvesting may begin from 3-4 months after planting depending on the variety.
- ✓ Harvest when the skin turns tan in colour, hard and when the stalk turns from green to brown.
- ✓ Butternuts are ready when the flesh is deep orange.
- ✓ Expected yield 20-30 tons/ha
- ✓ Harvest butternut when the fruit surface is completely dry (when there are no dews and rain)
- ✓ Fruits should be carefully cut off from the vine using secateurs, leaving about 1 cm of stalk attached to the fruit.
- ✓ Harvested fruits should not be exposed to sunlight or rainfall.
- ✓ Do not wash butternut but rather wipe with a damp cloth if fruits are dirty.
- ✓ Sort, grade and pack in different sizes ranging from small, medium to large according to market specifications.
- ✓ Store under shade in a well-ventilated room.

CABBAGE

1. BACKGROUND INFORMATION

Cabbage (*Brassica oleracea var capitata*) belongs to the Cruciferae family. Brassicae is one of the most important genus worldwide. It shares the same family with broccoli, cauliflower, rape, kale and mustard. It is a rich source of vitamin A, B and C. It also contains minerals like phosphorus, potassium, calcium, sodium and iron. Use of cabbage prevents constipation, increases digestion and appetite. Cabbage is commonly used as cooked vegetable and eaten raw as salad. Cabbage is grown throughout the country but it is more popular in the Highveld and Middleveld of Eswatini where it is available all the year round.

2. CLIMATIC REQUIREMENTS

- ✓ Cabbage can be grown under a wide range of climate but do best under cool, moist conditions (cool season crop).
- ✓ They require an optimum temperature of 18 to 24°C but mature cabbages can tolerate -3°C for a very short period.
- ✓ Several days at -1 to 4°C will induce premature flowering (bolting), and seed production.
- ✓ Dry periods followed by wet conditions will result in bursting of heads.

3. SOIL REQUIREMENTS

- ✓ Cabbages can be grown on a wide range of soils provided they are adequately fertilized or supplied with enough organic manure.
- ✓ However clay-loam soils with pH 5.5 – 6.5 are preferred.
- ✓ If pH is less than 5.3, lime the soil at least 2 months before planting.

4. VARIETY SELECTION

- ✓ The climatic conditions of Eswatini can favour the growing of cabbages all year round.
- ✓ However, in the Lowveld avoid summer period between December and January due to high temperatures (heat waves).
- ✓ Choosing the correct varieties for each season is very important (winter and summer varieties) and should be based on market preference.
- ✓ Disease resistance, uniformity at maturity and field holdability (days it takes from maturity to splitting) are major factors considered when choosing cabbage variety.

Varieties

- ✓ Summer: Hercules, Optima, Star 3301, Star 3303, Star 3311, Star 3316

- ✓ Winter: Conquistador, Green Coronet, Megaton

5. LAND PREPARATIONS

- ✓ Cabbages have got a shallow root system hence may not require too deep land preparation so ploughing and discing the land may be enough.
- ✓ If the land is virgin, ripping and ploughing may be necessary to bury the debris on the surface well in time (2 weeks) to allow decomposition.
- ✓ This may be followed by discing to bring the soil to a fine tilth.
- ✓ In high rainfall areas, planting on the ridges (15cm high) in summer and in furrows in winter is recommended.

6. PLANTING/ TRANSPLANTING

- ✓ Row spacing 90cm spacing and in row spacing of 40-60cm is recommended.
- ✓ Plant population is at least 24,000 to 27, 000 per hectare.
- ✓ Seedlings are ready for transplanting at 5-7weeks depending on the season.
- ✓ Thoroughly mix basal fertilizer with soil and irrigate day before planting (plant on moist soil) and spray to control cutworm.
- ✓ Make the planting hole that is 2 times the size of the root ball of seedling (avoid pushing seedlings into the ground).
- ✓ Insert the seedling in the hole such that the lower leaves (cotyledons) reaches soil surface.
- ✓ Irrigation should be given soon after transplanting of seedlings
- ✓ Early morning and late afternoon is the best time for transplanting or on a cloudy day.

PLANTING CALENDER

Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Highveld	S	B	B	B	S	S	S	B	B	B	S	S
Middleveld	S	S	B	B	S	S	S	B	B	B	S	S
Lowveld	N	S	S	B	B	B	S	S	S	S	S	N

B-Best planting time **S**-Suitable planting time **N**-Not suitable planting time

7. FERTILIZER REQUIREMENTS

- ✓ These are heavy feeders and require adequate nutrients in the soil for high yield.
- ✓ Amount of fertilizer depends on soil analysis results.
- ✓ Kraal manure at 25 to 30t/ha depending on type and level of decomposition is applied a month before planting.

- ✓ Cattle manure benefit microbial life and soil structure, and are excellent for stimulating plant growth.
- ✓ Basal fertilizer 600kg/ha of 2:3:2 (37) fertilizer (12 bags) in bands and should be thoroughly mixed with soil before planting

Topdressing

- ✓ 4 weeks after planting (WAP), apply LAN 5g/plant (2.5 bags/ha),
- ✓ 6 WAP 5g/plant LAN (2.5 bags/ha)
- ✓ Foliar feeds are also recommended to encourage rapid response to nutrient uptake

8. IRRIGATION MANAGEMENT

- ✓ Cabbages have an effective rooting zone of 60cm so irrigate to field capacity before planting and later apply according to requirements
- ✓ Ample soil moisture is necessary throughout the growing season to produce good cabbage.
- ✓ optimum soil moisture should be maintained by frequent irrigation during critical period of head formation and development
- ✓ Prolonged moisture stress and hot temperature encourage development of bitter tasting cabbages.
- ✓ Overhead and furrow irrigation is suitable where there is sufficient water while drip irrigation is ideal where water is scarce.

9. WEED CONTROL

- ✓ Ploughing of field 1-2 months before planting helps in reducing the existing weeds in field and also reduced the weed seed bank in the soil (pre-sprouting of weeds)
- ✓ Weeding by hoeing is essential for proper aeration to root system and control weeds to promote healthy and vigorous growth and productivity
- ✓ The first weeding should be done two to three weeks after transplanting

10. PEST AND DISEASE MANAGEMENT

- ✓ Under warm conditions, cabbages are susceptible to aphid and cabbage moths' attack. Bacterial black rot is more prevalent during summer (wet season).
- ✓ Crop rotation can reduce pests and disease incidence
- ✓ Spraying with chemicals should be done when temperatures are moderate, on a cloudy day, early in the morning or late in the afternoon.
- ✓ Never spray on windy and when rainfall chances are high.

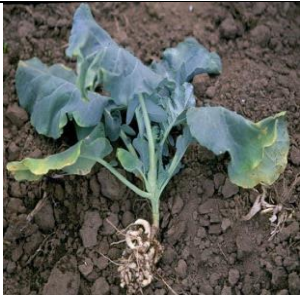
- ✓ A sticker (orosorb, nufilm and compliment) should be used in wet seasons to allow chemicals to stick
- ✓ Pruning of lower leaves promotes development of high quality heads

GUIDE FOR PEST AND DISEASE CONTROL IN CABBAGE

Pest/Disease	Picture of pest/disease	Symptoms	Recom. Chemicals	Application rate/20 L water	Withdrawal period
Cutworm		Cutting of young plants at the base	- Cypemetrine - Decis - Cutworm bait	20ml 5ml	
Diamond back moth		Larva feeds on the lower leaf surface, leaving the upper epidermis intact thereby creating a “window-paning” effect.	- Malasol - Warlock	12 ml 130ml	7 days 3days
Aphids		Colonies of aphids clustered on young stem, Distortion of young shoots	- Decis, - Profenofos - Aphicide Plus	5 ml 20 ml 100ml	3 days 7 days 4 days

Pest/Disease	Picture of pest/disease	Symptoms	Recom. Chemicals	Application rate/20 L water	Withdrawal period
America bollworm		The larvae feed on the leaves and cause severe damage in the early stages of growth by destroying the growing points of the plants	- Cypemetrine - Decis	20ml 5ml	7 days 3 days
Nematodes		Plants become stunted and may show signs of moisture or nutrient stress.	- Oxadate 310SL - Carbofuran	<u>Seedbed:</u> 40ml/10lt water, drench seedbed 48 to 24 hours before transplanting with 2lts of solution per m ² of seedbed surface. <u>After</u> <u>transplanting:</u> 800ml/100lt water, apply 250lts spray solution per hectare as a foliar application 2 weeks after transplanting. Repeat after 3 weeks with 500lts	

Pest/Disease	Picture of pest/disease	Symptoms	Recom. Chemicals	Application rate/20 L water	Withdrawal period
				spray solution per hectare.	
Sclerotonia rot or white mould		Above-ground parts of infected plants may be covered with a white cottony growth. The tissue beneath the mould turns soft and watery.	- Funginex, - Bravo, - Copper oxychloride - Dithane M45, - Amistar - Oscar	25ml 50ml 60ml 40ml 50ml 15	1 day 3 days 3 days 7 days 7 days 10 days
Downy Mildew		Large, angular or blocky, yellow areas visible on the upper surface	- Funginex, - Bravo, - Copper oxychloride - Dithane M45, - Amistar - Oscar	25ml 50ml 60ml 40ml 50ml 15 ml	1 day 3 days 3 days 7 days 7 days 10 days

Pest/Disease	Picture of pest/disease	Symptoms	Recom. Chemicals	Application rate/20 L water	Withdrawal period
Brassica stunting disease		Stunted plants, flattening and purpling of the leaves, side shoot development	Control the vectors through use of: - Agromectin - Decis - Malasol	12 ml 5 ml 12 ml	7 days 3 days 7 days
Clubroot		Galls develop on the root hairs, rotting of the root system and stunted growth	- Use certified seed - Lime the soil - Practice crop rotation - Grow transplants in fumigated land		
Black rot		White to light brown lesions with a purple to black margin develop on the stem and on leaves. The lesions have small black dots in the centre. The centre of the lesion gets woody and cracks.	- Use resistant varieties - Rotate to fields that have not been planted with cole crops in past 3 years - Clean out and burn plant residues or plough down residues immediately after harvesting		

11. HARVESTING

Maturity index

- ✓ Cabbage are ready for harvest at 75 to 120 days from transplanting depending on variety and season.
- ✓ Harvest maturity based on head compactness and firmness to the touch or when wrapper leaves are spread and the head is exposed.
- ✓ Delaying harvest even a few days beyond maturity can result in split heads and increased incidence of field disease, particularly during wet weather.

Harvesting procedure

- ✓ Cabbage is harvested by hand by bending the head to one side and cutting it with a sharp knife
- ✓ Avoid snapping or twisting it, as this practice damages the head and results in jagged appearing stems which extend too far out from the base of the head thus encouraging rotting.
- ✓ The stalk should be cut flat and as close to the head as possible, yet long enough to retain two to four wrapper leaves.
- ✓ Wrapper leaves protect cabbage during transportation
- ✓ Cabbage stumps should not be left on the ground as they may cause pests and diseases
- ✓ Yield 50-60t/ha

Postharvest handling

- ✓ Harvesting be conducted during the coolest time of the day, preferably in the morning
- ✓ Cabbage should be put in baskets or well-ventilated picking containers and taken out of the field immediately after harvest.
- ✓ Harvested cabbage is particularly susceptible to wilting and should be removed from the field and direct sunlight as soon as possible.
- ✓ The cabbage should be taken to a well-ventilated shaded area for packing and transport to market
- ✓ Spraying clean water on harvested cabbage leaves can help prevent dehydration
- ✓ The optimal storage temperature for all cabbage types is 0°C and can store for 4 to 6 weeks.

Grading and sorting

- ✓ Yellowed, damaged, or diseased wrapper leaves should be removed.
- ✓ Heads with insect damage and other defects should be discarded.
- ✓ Cabbage should be sorted according to size, shape, and compactness of the head
- ✓ Cabbages are generally packed in mesh bags holding about 20 kg
- ✓ Uniformity of head size and the proper count per bag are important

CARROT

1. Background Information

Carrot (*Daucus carota* L.) is a widely grown root vegetable of the Apiaceae family. It is an important source of alpha- and beta-carotene, precursors of vitamin A in human nutrition, in many cultures worldwide. Their early use was mainly medicinal, to cure stomach problems and treat wounds, ulcers, and liver and kidney ailments

2

2. Climatic Requirements

- ✓ The carrot is a cool weather crop but some cultivars can tolerate warm to high climates. Temperatures below 10 °C cause longer, more slender and paler roots. Extended periods of hot weather may produce fibrous, reduce root length and unmarketable carrot.
- ✓ Optimum growing temperature for carrot is 15- 24°C.
- ✓ Carrots require a steady supply of moisture and it must be maintained at above 50 % of available moisture throughout growth. Generally, carrots require approximately 25 mm of water per week but under warm, dry conditions 50 mm will be required.

3. Soil requirements

- ✓ Deep (20-30cm), loose, well-drained sandy to loamy soils, not subject to capping. pH of 5.5 to 6.5 are ideal for carrot production.
- ✓ The crop produced in humus-rich soils tends to increase in foliage excessively and forms forked and hairy carrots.
- ✓ The roots also tend to be more rough and coarse on the outside. Alkaline soils should also be avoided as carrots are very sensitive to saline soils.

4. Crop Selection

Crop Selection is widely influenced by market preference

Heat Tolerant Varieties	Cold Tolerant Varieties
Chantenay	Nantes
Kuroda	Major
Wortel	Scarlet Nantes
	Bentley

Planting times

Area	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Highveld	S	B	B	S	S	S	S	B	B	B	S	S
Middleveld	S	S	B	B	S	S	S	B	B	B	S	S
Lowveld	N	N	S	S	B	B	S	S	N	N	N	N

B – Best time

S – Suitable time

N – not suitable

Seeds Procurement

Carrots are only planted by direct seeding. A smooth and well prepared field is required.

5. Land Preparation

- ✓ The land should be well prepared by ploughing 20 to 30 cm deep to break up clods.
- ✓ The soil should also be as level as possible, have a good crumb structure, enough moisture and be free of un-rotted plant material.
- ✓ If you decide to bury the crop residues, wait for 8 weeks until they decompose.
- ✓ Fumigate soil to control nematodes.

6. Planting

- ✓ The rows are generally spaced from 20 cm to 40 cm apart. In double or triple rows, with between set of rows from 40 – 60 cm.
- ✓ The seeds are directly sown in the field on ridges or raised beds.
- ✓ Row planting is preferred to broadcast sowing.
- ✓ The seeding depth should be 2.5 to 4.0 cm in loose.
- ✓ Planting depth should be shallow on heavier soils and in colder months.
- ✓ Slightly deeper planting is recommended in summer when the soil dries out quickly.
- ✓ The chance of a successful establishment of the crop will be increased if the seed is sown in moist soil and only if the soil is kept moist.

Seeding Rate

- ✓ Always mix seed with sand when planting with hand,
- ✓ Direct seed planter can also be recommended.
- ✓ Seeds should be 2kg/ha
- ✓ Carrot seeds germinate in 12 – 18 days
- ✓ Thin plant after 3-4 weeks after germination on wet or moist soils
- ✓ Final stand should have a spacing of 3cm between plant

7. Fertilizer Application

NB: Fertilizer recommendations should be based on soil analyses

Basal fertilizer

As a general guide, 100 kg/ha (2 bags) fertilizer mixture of 2:3:4 (30) should be worked into the soil before planting.

Top dressing

Carrots have low nitrogen requirements and good yields can be obtained with 80 kg/ha LAN 28% applications at 4-8 weeks after germination. Ensure soils are moist before application.

8. Irrigation

- ✓ The soil should never be allowed to dry out.
- ✓ Too much moisture causes short carrots with light color and a larger diameter.
- ✓ The field should be irrigated lightly immediately after sowing for rapid, uniform seed germination and stem establishment.
- ✓ Watering should gradually be reduced to prevent longitudinal splitting of the roots when the crop approaches maturity.
- ✓ Water stress during root development also causes cracking of the roots, which also become hard.

9. **Weed control**

- ✓ Carrot seedlings grow slowly, so it's important to keep weeds under control during early grow
- ✓ Weeds should not at any time be allowed to compete with crop.
- ✓ Allow weed to pre-sprout, plough back at least twice before planting to minimize incidence of weed infestation.
- ✓ Weeds can be controlled mechanically, by hand, using a hoe, chemically or by combining all these methods.
- ✓ Chemicals; Sencor 480SC, Afalon SC and Linex 4F

10. Pest and Disease Management

a. Pest Control

Name of pest	What impact does it have on plants	Picture of damage caused by pest	How can it be controlled	How much pesticide should be mixed in 20L of water	Withdrawal Period
Aphids	They suck juices from the plant resulting in stunted growth		Agromectin Malasol Remove weeds on edges of field	12 ml 35 ml	7 days 7 days
Weevil	The adult beetles feed on plant foliage. Females lay eggs in the carrot roots through a small puncture wound.		Agromectin Malasol	12 ml 35 ml	7 days 7 days

b. Disease Control

Name of disease	What impact does it have on plants	Picture of disease	How can it be it be controlled	How much pesticide should be mixed in 20L water	Withdrawal Period
Soft rot	In very poorly drained soils, tip rot occurs in the field. Soft rots are characterized by a watery, smelly decay		-Avoid late top dressing -Use resistant varieties -Plant on raised beds in poorly drained soils -Avoid injuring roots during weeding -Practice crop rotation – rotate to non-root crops		

Name of disease	What impact does it have on plants	Picture of disease	How can it be controlled	How much pesticide should be mixed in 20L water	Withdrawal Period
Sclerotinia rot	Early signs of the disease are water soaked spots at the base of the foliage. If humidity is high, the infection is accompanied by a cottony white growth on the carrots		- Benomyl - Do not plant in poorly drained soils - Avoid low plant densities - Infected fields should be planted with non-susceptible crops for 3 years. - Weed plot to improve air movement within the crop canopy.	40g	
Root Knot	Nodules distort and deform the vegetable.		- Soil should be fumigated before planting - Practise crop rotation - Leave land fallow in summer to reduce nematode numbers – fallow land should be weed free		

Name of disease	What impact does it have on plants	Picture of disease	How can it be it be controlled	How much pesticide should be mixed in 20L water	Withdrawal Period
Powdery Mildew			Preventative; Copper oxychloride Dithane Bravo Control; -Ridomil	Preventative; 60g 40g 40ml Control; 20g	3 days 7 days 3 days 7 days

c. Physiological Disorders

Name of physiological disorder	Symptoms of physiological disorder	Picture of physiological disorder	How it can be avoided or corrected
Greening	Green colours occurs at the shoulders of the carrots due to exposure to light		Hilling carrots during the season will help to control greening. Thick stands create enough shade to protect the roots from the sun.
Misshappen roots	-Can be caused by a number of factors such as: hardpan, cultivars, compacted soil and over-irrigation. -Hardpans prevent the root from growing straight down. -Untimely or uneven precipitation causes the root not to grow straight.		Plough soil deeply prior to planting -Ensure a finely worked seedbed by harrowing -Avoid planting carrots in heavier soils -If you have heavier soils, the use of raised beds may reduce misshappen roots
Forked roots	Can be caused by a number of factors such as: - Compacted soil - Too much water - Heavy fertilization - Close spacing		-Ensure soil is not dry by irrigating uniformly. -Avoid over watering -Always apply fertilizer based on recommendations of a soil test. -Plough soils deeply

Name of physiological disorder	Symptoms of physiological disorder	Picture of physiological disorder	How it can be avoided or corrected
			-Do not use compost Ensure that root tip is not damaged
Hairy roots	Hairy roots are caused by too much irrigation of carrots		-Avoid too much irrigation -Avoid application of too much manure
Carrot Cracking			

8 Harvesting

- ✓ Expected yield is 15-25 ton/ha
- ✓ Light irrigation is required before harvesting, a day before.
- ✓ Do not harvest early in the morning if the soil is cold, as this may cause roots to crack horizontal.
- ✓ When forking, the fork should be 15cm away from the crop.
- ✓ Carrots harvestings depending on varieties which is 70-100 days after planting, when they reach maturity. The diameter should be at least 20mm
- ✓ Uproot and bite to determine if it has reached maturity – if carrot has accumulated sugar it means they have reached maturity.
- ✓ Use fork to harvest carrots.
- ✓ After harvesting, the carrots are placed in a shade at the field in crates before washing.
- ✓ Carrots should be washed carefully to avoid as little damage as possible to the root surface

Post- harvest practices

Sorting and grading

Carrot is graded according to size and it shouldn't have the following;

- ✓ Free from pest's damage
- ✓ Free from bacterial and fungal decay
- ✓ Free from bruising
- ✓ Free from secondary roots
- ✓ No forked carrot
- ✓ No woody carrot
- ✓ No broken carrot
- ✓ Free from abnormal external moisture
- ✓ Free from frost damage
- ✓ Free from foreign smell and/taste
- ✓ Must be clean and free from foreign matter, including soil
- ✓ Free from blemishes
- ✓ Not be running to seed
- ✓ Free from sun-scorch
- ✓ Fresh and firm and show no sign of withering
- ✓ Have fresh, green and sound foliage not longer than 50mm; Provided that if topped, it must be evened off or cut off at the top of the root, without damaging it
- ✓ No wilted tips
- ✓ Leaves must be intact, green, not damaged, free from rust and sunburn

2. Packing

After washing and rinsing with a fungicide, the crop is dried and packed according to customer's specifications. Recommended packaging material by the market is used and the produce is kept in a cool (under shade) and dry environment.

3. Storage

The environment must be dry to avoid fungal attack, and the temperature must be kept at 13-16°C and the relative humidity at 90 %.

GARLIC

1. Background

Garlic (*Allium sativum*) is sometimes used as a repellent for insects attacking other vegetables. Garlic is native to Europe and central Asia. It was used in England by the first half of the 16th century and was later taken to the Mediterranean area. It is used in all food preparation for its pungent flavour as a seasoning or condiment. Garlic is classified as a hardy crop, which means that it can survive low winter temperatures. Garlic is a relatively good source of calcium, phosphorus, and potassium. Its leaves are sources of protein and of Vitamins A and C. Garlic is said to contain antibiotic substances that inhibit the growth of certain bacteria and fungi. People in the rural areas use garlic to treat wounds, toothache, and epilepsy. Scientific experiments, for instance, have shown that certain compounds in garlic block the blood platelets from forming into blood clots, which could cause heart attacks (coronary thrombosis) and strokes.

2. Climatic requirements

- ✓ The bulb formation in this crop is influenced by temperature and day length, although to a lesser extent than onions.
- ✓ Most of the conditions that are suitable for the production of onions also apply to garlic. The suitable growth temperature for garlic is 13 °C to 24 °C.

3. Varieties

- ✓ Egyptian white garlic
- ✓ Chesnok red garlic
- ✓ Vietnamese red garlic
- ✓ German porcelain garlic
- ✓ Music garlic

4. Planting

Planting Calendar

Climatic region	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Highveld	S	B	B	B	S	N	N	S	S	S	S	S
Middleveld	S	B	B	B	B	N	B	S	S	S	S	S
Lowveld	N	S	B	B	B	N	S	S	N	N	N	N

B – Best time

S – Suitable time

N – not suitable

- ✓ The general recommendation for spacing the divided cloves is 10 cm, with a row spacing of 20-30 cm. Plant population is 300 000- 500 000 garlic bulbs per hectare.
- ✓ 900kg per ha of seed/cloves are used
- ✓ Cloves can be planted approximately 50 mm deep on the raised beds or on flat ground, manually or by using machinery.
- ✓ The planting date of garlic differs from one area to another. However, in Eswatini the general recommendation is from February to May.
- ✓ Mulch is applied after planting. Mulch is evenly laid on the field with a thickness of 3-5 cm. Mulch controls soil moisture as well as the growth of weeds. Plastic mulch can be used in tunnel production.

5. Fertilization

- ✓ The first step before planting is to incorporate the compost into the soil as it improves not only the soil's fertility but also its structure.
- ✓ At planting, about 125 g of 3:2:3 can be applied per m² using the broadcasting method.
- ✓ During the growing period, which can be 6 to 8 weeks after planting, a light side-dressing of 40 g of 2:3:4 (30) can be applied per m² of the garlic field (400 kg/ha).
- ✓ Light application of LAN at a rate of 150kg per hectare. Heavy application of LAN encourages leave growth and reduces bulb formation and vigour.

6. Garlic pest and disease control measures in production

Name of disease		What impact does it have on plants	How can it be controlled	How much pesticide should be mixed in 20L of Water	How many days should be waited before harvesting
Downy Mildew		Grey to purplish mounds on the leaves. Leaves turn pale green, then yellow which eventually collapse and die off. Downy mildew is favoured by low temperatures and high humidity.	Dithane M45	40g (Preventative)	Dithane – 14 days
			Copper oxychloride	60 g (Preventative)	Copper oxychloride – 3 days
			Bravo	40 ml (Preventative)	Ridomil – 7 days
			Ridomil	40g (Control)	Bravo – 3 days
Purple blotch		Small water-soaked areas on leaves turn brown, then purple with yellow centres	Dithane M45	40g (Preventative)	Dithane – 14 days
			Copper oxychloride	60g (Preventative)	Copper oxychloride – 3 days
			Bravo	40ml (Preventative)	Ridomil – 7 days

Name of disease		What impact does it have on plants	How can it be it be controlled	How much pesticide should be mixed in 20L of Water	How many days should be waited before harvesting
			Ridomil	Ridomil - 40g (Control)	Bravo – 3 days
Black mould		Occurs between dry and dead outer scales and the first inner scales of the bulb. Invaded scales first become water-soaked, under dry conditions disease scales dry and shrivel	Dithane M45	40g (Preventative)	Dithane – 14 days
			Copper oxychloride	60g (Preventative)	Copper oxychloride – 3 days
			Bravo	40ml (Preventative)	Ridomil – 7 days
			Ridomil	Ridomil - 40g (Control)	Bravo – 3 days
Soft rot		Centre of leaves become pale and collapse. Infected inner scales of bulbs become water soaked and later become yellow or pale brown.	Xanbac	Xanbac – 50 ml	Xanbac – 3 days
			Avoid sprinkler irrigation once garlic start to form bulbs		
Pink Root		appears on the roots of seedlings and older plants.	use resistant cultivars		

Name of disease		What impact does it have on plants	How can it be controlled	How much pesticide should be mixed in 20L of Water	How many days should be waited before harvesting
		The roots turn pink, shrivels and dies			
Rust		Small white or yellow flecks appear on leaves. Can impact bulb development and stunting in plants.	Leaves should be cut off if it is infected before harvest. Fungicides should be applied during development.	Ridomil - 40g	Ridomil – 7 days

Common pests in onions and their control measures

Name of pest	Picture of damage caused by pest	What impact does it have on plants	How can it be controlled	How much pesticide should be mixed in 20L of Water	How many days should be waited before harvesting
Thrips		They suck juice from lower side of leaves. Leaves appear silvery with sunken areas that later dry resulting to weakened plants and reduced yield. Heavy feeding can kill young plants	- Decis Forte - Malasol	- 5ml - 35 ml	2 Days 3 7 days
Destroy crop residues after harvest. Farmers should practice crop rotation					
Army worm		They bore into onion leaves and feed leaving the outside of leaf almost intact.	- Fastac - Dipel	- 10ml - 20 g	21 days
Cutworm		Cut off plants near the surface of the soil	Decis Forte Cutworm bait	5 ml	2 days

7. Irrigation

- ✓ Garlic can be grown successfully, using furrow, sprinkler, or drip irrigation.
- ✓ Garlic has a relatively shallow root system and it is therefore sensitive to moisture stress throughout the growing season.
- ✓ The soil type on which garlic has been planted does not affect the total volume of water needed, but does determine the frequency of water application.
- ✓ Mulching is recommended to reduce the rate of moisture loss from the soil surface.
- ✓ In preparing for planting, it is necessary to irrigate the field a day or two days earlier if soil moisture is not sufficient.
- ✓ In case the soil becomes too wet after irrigating, the field should be allowed to dry until the desired moisture level is attained.
- ✓ In clay loam soil, the roots dig down as deep as 59 mm so enough moisture is essential within the root zone during the vegetative growth.
- ✓ The frequency of irrigation depends on the soil type and occurrence of rainfall during the growing period. Sandy soil requires a more frequent irrigation.
- ✓ Flash irrigation can be applied when crevices or cracks on clay loam soils appear.
- ✓ Water should never be allowed to stay in the field beyond six hours.

8. Weed control

- ✓ Weeds are controlled by cultivation or hand-hoeing or with registered herbicide application.
- ✓ Deep cultivation close to the plants should be avoided as root damage with subsequent yield losses may occur.
- ✓ All these methods may be integrated for best control.

9. Harvesting and storage

- ✓ Garlic matures 6-9 months after planting.
- ✓ Generally, early planting has a longer period of maturity than the late planting. Indices of maturity are the softening of the main stem above the bulb and the yellowing of 75% of the leaves.
- ✓ It requires pulling the individual plants by hand.
- ✓ The harvested bulb can be sun or air-dried. Sun drying ranges from 3 to 4 days.
- ✓ Garlic is rarely kept in cold storage.
- ✓ The farmers store their produce under ambient storage conditions in several ways:
 - By hanging the bundles in rows with bamboo stick or lumber in a well-ventilated place or above the store in the kitchen.
 - To minimize pest infestation during storage, clean and dry the area.
 - Before the stocks are stored, spray the area with Malathion or other insecticides recommended for the control of storage pest.
 - Regularly spray the surrounding with the recommended insecticides to prevent the occurrence of insect pests.

ONION

1. Background information

Onion (*Allium cepa* L.) have been grown and used as food for centuries. Mature and immature onions are used to flavor food, as well as in salads and pickles. They are sometimes used as a repellent for insects attacking other vegetables. They are one of the few vegetable crops that can be kept for a longer period and long-distance transportation

2. Climatic requirements

- ✓ Onion is sensitive to photoperiod. They grow best in temperatures ranging from 18 °C to 22 °C.
- ✓ Higher temperatures (25 –27 °C) will promote bulb formation, while lower temperatures (8–13 °C) will induce flowering

3. Soil requirements

- ✓ Deep well-drained soils are required as onions are sensitive to water logging. The best results can be obtained on loamy soils which are deep and well drained, with a pH between 5.5 and 6.5.

4. Crop selection

Varieties

Texas Grano, Granex 33, pyramid, Australian brown, Explorer, San, Red Creole

5. Planting Calendar

Climatic region	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Highveld	S	B	B	S	N	N	S	S	S	S	S	S
Middleveld	N	S	B	B	B	B	B	B	B	S	N	N
Lowveld	N	S	S	B	B	B	S	S	N	N	N	N

B – Best planting time

S- Suitable planting time

N – Time not suitable for planting

6. Land preparation

- ✓ Plough down weeds/ residues 2-4 weeks before planting (decomposition)
- ✓ Apply 15 t/ha kraal manure especially in the Highveld where phosphorus levels are low
- ✓ Discing and harrowing the field to incorporate the kraal manure into the soil.
- ✓ Onions have a relatively shallow root system, with most of the feeding roots occurring in the top 200 mm of the soil

7. Seedbed

- ✓ The soil in the seedbed should be a fine tilth.
- ✓ Sow seeds in rows to ensure enough ventilation and make weed control easier
- ✓ Make furrows 15cm apart and sow seed at depth of 10 to 15mm. Avoid sowing too thickly as this results in spindly plants which transplant poorly
- ✓ Sowing densities should be between 1500 and 2500 seeds per 1 m² (about 7g)
- ✓ If the days are very hot, a thin layer of grass should be sprinkled on the soil as mulch and should be removed when the plants start to emerge (7-14days after sowing). If left too long, the plants become long and thin and get sunburn
- ✓ Seedlings 12-20 cm long will be ready to transplant in 6-8 weeks. Do not trim the leaves before transplanting
- ✓ Make furrows 2-4cm deep and lay the white part of the seedlings in the furrow
- ✓ Use a rake or spade to cover the roots and compact the soil around with the back of the rake or by hand
- ✓ Take care not to plant the seedlings too deep as this tends to produce elongated bulbs.

8. Transplanting/ planting

- ✓ Planting beds should be 1 to 1.2m wide in the field with 50 cm to 70 cm between beds (walkway).
- ✓ Remove soil from the paths to raise the bed 8-10cm high
- ✓ Plant onions 7-10cm apart in rows that are 20-25cm apart (50-60 plants per 1m²)
- ✓ Heavy pipe can be dragged behind the tractor to flatten ridge tops, height of the remaining bed can be somewhat controlled by lengthening or shortening the chains.
- ✓ Fertilizer application is based on soil test results. Basal fertilizer: 100 g of 2:3:2 (37) or 2:3:4 (30) per 1 m² adding up to 550 kg/ha (11 bags of 2:3:2 (37))
- ✓ Spacing in rows: 7-10cm but 5cm used if some will be sold green and not more than 2.5 cm deep

- ✓ When using furrow system, plant on either side of the furrow just above where the water reaches.
- ✓ 3.5-4kg of seed per ha. Seedlings 750000 – 950000 plants per ha

9. Top dressing and weed control

- ✓ The crop is a heavy feeder and needs nitrogen and potassium, but remember that too much nitrogen late in the season can cause too vigorous leaf growth, delayed bulb formation/ development of thick necked plants
- ✓ Phosphorus and potassium are required throughout the season
- ✓ Topdressing- 100kg LAN+ 100kg KCL/ha every 3 weeks after transplanting especially if the soil is sandy until bulb initiation
- ✓ Apply them 5-15cm from the plant and carefully work in the top dressing but be careful not to damage the roots
- ✓ Top dress immediately after irrigation; this will allow the fertilizer to start working immediately
- ✓ Stop fertilizing when the onions start to bulb
- ✓ Control weeds to avoid competition for nutrients and water particularly when the plant is small
- ✓ Weed carefully to avoid damaging the roots.
- ✓ Ensure bulbs are not covered by the soil.
- ✓ Stop working between the rows when the foliage becomes dense.

10. GUIDELINES FOR CONTROLLING DISEASES IN ONION PRODUCTION

Name of disease	Picture of damage caused by pest	What impact does it have on plants	How can it be it be controlled	How much pesticide should be mixed in 20L of Water	How many days should be waited before harvesting
Downy Mildew		- Grey to purplish mounds on the leaves. - Leaves turn pale green, then yellow which eventually collapse and die off. - Downy mildew is favoured by low temperatures and high humidity.	- Dithane M45 - Copper oxychloride - Bravo - Ridomil	- 40g - 60 g - 40ml - 40g	- 14 days - 3 days - 3 days - 7 days
			- Dithane M45	- 40g	- 14 days

Name of disease	Picture of damage caused by pest	What impact does it have on plants	How can it be it be controlled	How much pesticide should be mixed in 20L of Water	How many days should be waited before harvesting
Purple blotch		Small water-soaked areas on leaves turn brown, then purple with yellow centres	- Copper oxychloride - Bravo - Ridomil	- 60 g - 40 ml - 40g	- 3 days - 3 days - 7 days - 7 days
Black mould		Infected bulbs may show blackening at the neck, streaks or spots of black on or beneath the outer scales, and black discoloration in bruised areas	- Dithane M45 - Copper oxychloride - Bravo - Ridomil	- 40g - 60g - 40ml - 40g	- 14 days - 3 days - 3 days - 7 days

Name of disease	Picture of damage caused by pest	What impact does it have on plants	How can it be it be controlled	How much pesticide should be mixed in 20L of Water	How many days should be waited before harvesting
Rust		Brown spots on leaves	- Dithane M45 - Copper oxychloride - Bravo - Ridomil	- 40g - 60 g - 40ml - 40g	- 14 days - 3 days - 3 days - 7 days
Soft rot	 	Centre of leaves become pale and collapse. Infected inner scales of bulbs become water soaked and later become yellow or pale brown.	- Xanbac	- 50 ml	- 3 days
Avoid sprinkler irrigation once onions start to form bulbs					

Name of disease	Picture of damage caused by pest	What impact does it have on plants	How can it be it be controlled	How much pesticide should be mixed in 20L of Water	How many days should be waited before harvesting
Pink Root	 	Wilting at the tips and gradually dieback before they are fully matured. Affected plants have rotten roots with some seen as pink when pulled up.	use resistant cultivars		

11. Common pests in onions and their control measures

Name of pest	Picture of damage caused by pest	What impact does it have on plants	How can it be controlled	How much pesticide should be mixed in 20L of Water	How many days should be waited before harvesting
Thrips		They suck juice from lower side of leaves. Leaves appear silvery with sunken areas that later dry resulting to weakened plants and reduced yield. Heavy feeding can kill young plants	- Decis Forte - Malasol	- 5ml - 35 ml	4 Days 5 7 days
Destroy crop residues after harvest. Farmers should practice crop rotation					
Army worm		They bore into onion leaves and feed leaving the outside of leaf almost intact.	- Fastac - Dipel	- 10ml - 20 g	21 days
Cutworm		Cut off plants near the surface of the soil	Decis Forte Cutworm bait	5 ml	2 days

6 Irrigation

- ✓ After transplanting, keep the soil moist for the first 5 days to overcome transplanting shock
- ✓ They require approximately 400-600mm of moisture per growing season
- ✓ Onion roots are concentrated in the upper 30mm of the soil and therefore the soil must be kept moist
- ✓ Avoid moisture stress during bulb formation and development
- ✓ Do not water onions 3 weeks before harvesting

7 Harvesting,

- ✓ Green onions are harvested early when bulbs reach market specification
- ✓ Dry bulbs are ready for harvesting at 3-4 months after transplanting, neck fall is the indication of maturity
- ✓ They are harvested once 50 % of the leaves have lodged
- ✓ Do not leave on onion plants in the soil for too long
- ✓ Onions are lifted by loosening the soil with a fork or harvester.

8 Curing and storage

- ✓ Make bundles and tie the leaves together and then hang them from a ceiling of a storeroom to dry.
- ✓ They can be also dried in the field by placing them in the windrows in such a way that the leaves protect the bulbs against sunburn. If it rains turn the plants over.
- ✓ Once the necks of the bulbs have dried completely the leaves can be cut and the bulbs stored.
- ✓ For fresh marketing of short-day onions, the onions are partially dried and then marketed immediately in order to get high prices
- ✓ Yield: 20-40t/ha
- ✓ After drying and cleaning, onions must be stored in a dry place. They should be matured, thoroughly dried and not damaged.
- ✓ The storeroom should be well ventilated and have a low temperature and low humidity.
- ✓ Turn the bulbs often so that all sides of the entire bulb are exposed to air and light at regular intervals.
- ✓ Store in layers not thicker than 10 cm. Remove rotten bulbs immediately.
- ✓ Onions must be sorted, graded and packed in different sizes ranging from small, medium and large according to market specifications.

PEPPER

1. Background information

Peppers (*Capsicum annuum*) are also known as bell peppers or capsicum. The colors may vary from yellow, red, orange, green, purple and brown. Peppers are from the *Solanacea* family which includes other vegetables like tomatoes, potatoes, eggplant, etc.

2. Climatic requirements

Pepper is a warm season crop sensitive to frost or cold temperatures. Optimum mean temperatures for its growth are 20-27°C. Abortion of flowers may occur when temperatures rise above 32°C. Temperature below 15°C may delay growth.

3. Soil requirements

- ✓ Pepper is adaptable to a variety of soil types; however, they grow well in loamy soils with a depth of up to 40cm – 60cm.
- ✓ The optimum pH ranges from slightly acidic to neutral (5.5 – 6.5).
- ✓ Soil analysis is recommended for optimum yields.

4. Varieties

- ✓ Variety selection should be determined by market requirement, season, growth, habit and pests and diseases resistance

Sweet pepper varieties:

Open pollinated: California wonder, Jupiter and Capricon

Hybrid: Star 6653, Duke, Revelation, Pfeiffer

Hot pepper varieties: Furry, Jalapino, Long slim cayenne, Birds eye

5. Cropping calendar

	Months											
Area	JAN	FEB	MAR	APRL	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
Highveld	S	N	N	N	N	N	N	S	B	B	B	S
Middleveld	S	B	B	S	N	N	S	B	B	B	S	S
Lowveld	N	S	B	B	S	S	S	B	S	S	N	N

B – Best time

S – Suitable time

N – not suitable

Land preparation

- ✓ Plough at a depth of 30-40cm and apply the recommended dose of lime and manure.
- ✓ Harrow to incorporate soil amendments until it is well pulverized.
- ✓ Form flat ridges 15-20 cm high or furrows at least 90cm apart.

6. Planting/transplanting

Seedling selection

- ✓ Healthy, hardened seedlings should be sourced from a **reputable** seedling producer.
- ✓ A healthy seedling should have a solid green color, 15cm height, short internodes, and healthy root system with root hairs.
- ✓ Seedlings should be free from insects and diseases
- ✓ A good seedling is in the four- or five-leaf stage (about 4 -6weeks old) and at least 15cm tall.
- ✓ Seedlings should be planted 40-45cm between plants and 90cm between rows.
- ✓ Insert the seedling in the hole such that lower leaves(cotyledons) reach soil surface
- ✓ Early morning and late afternoon is the best time for transplanting

7. Fertilizer application

- ✓ Fertilizer application should be done as per soil analysis results.
- ✓ Adequate organic manure is necessary at a rate of 25 – 35 tons of compost or manure per hectare.
- ✓ As a general recommendation 300kg/ha (6 bags) of 2:3:4 (39) should be applied as basal dressing.
- ✓ Top dress with LAN, 200 kg/ha (4 bags). Split applications from 6 – 12 weeks after planting.
- ✓ Apply 5:1:5 (45) at 200 kg/ha (4 bags) every after each heavy picking of fruits.

8. Irrigation

- ✓ It is important to supply sufficient water at critical times such as after sowing or transplanting.
- ✓ Drip irrigation is highly recommended but overhead and furrow irrigation can also be used.
- ✓ Irrigation requirements is determined by the soil types, method of irrigation, crop growth stage and the prevailing weather conditions.
- ✓ Critical stages include early establishment, flowering and fruit development.
- ✓ Irrigation should be done a day before and soon after transplanting.
- ✓ Seedlings should be moist before transplanting

9. Trellising

- ✓ Some varieties may require trellising especially in summer months to prevent sunburn.

10. Weed control

- ✓ Efficient weed control measures should be practiced to reduce weed and plant competition for growth resources like light, water and nutrients.
- ✓ Mulching, manual weeding are some of the practices that can be used for weed control.

11. Pests and diseases management

a. Pest Control

Name of pest	What impact does it have on plants?	Picture of damage caused by pest?	How can it be controlled?	How much pesticide should be mixed in 20L of water?	How many days should be waited before harvesting?
Cutworm	Feeds on seedlings at the ground level causing them to fall		- Decis - Cypermetrin - Karate	- 5ml - 15ml - 6ml	3 days 7 days
Red spider mite	Feeds on underside of leaves causing a yellow or bronze color. Leaves affected by mites curl downwards.		1.Ensure sanitation of implements when moving across fields. 2. Plough down and incorporate all crops residue after harvest. 3. Keep field edges clean. 4. Uproot		

Name of pest	What impact does it have on plants?	Picture of damage caused by pest?	How can it be controlled?	How much pesticide should be mixed in 20L of water?	How many days should be waited before harvesting?
			infected plants and throw them away. 5. Spray with agromectin or profenophos	15ml 100ml	3 days. 4 days
American Bollworm	Feeds on fruit		Decis Forte Cypermethrin Remove infected plants.	5ml 20ml	3 days 7 days
Aphids	Suck plant nutrients resulting in stunted plants. Leaves may also become yellow and deformed. Aphids serve as a		Malasol Acephate Aphicide Decis Forte Remove all crop remains soon after harvesting. Remove	35ml 20g 5ml	1 day 3 days 3 days

Name of pest	What impact does it have on plants?	Picture of damage caused by pest?	How can it be controlled?	How much pesticide should be mixed in 20L of water?	How many days should be waited before harvesting?
	vector for most plant viruses.		weeds surrounding field.		
Thrips	Insects feed on plant juices from smaller plants and flowers. Leaves curl upwards developing a boat shaped appearance. Damaged fruit is distorted.		Decis Forte Cypermethrin Malasol 1. Use resistant varieties. 2. Remove all crop remains soon after harvesting.	5ml 20ml 35ml	2 days 7 days 1 day

Name of pest	What impact does it have on plants?	Picture of damage caused by pest?	How can it be controlled?	How much pesticide should be mixed in 20L of water?	How many days should be waited before harvesting?
					
Corn borer	Larvae bore into and feed on fruitcausing decay. Damaged small fruits fall from plant.		Decis Forte Cypermethrin Avoid planting pepper closer to maize. Remove all crop remains soon after harvesting. Remove weeds around field edges.	5ml 20ml	3 days 7 days

Name of pest	What impact does it have on plants?	Picture of damage caused by pest?	How can it be controlled?	How much pesticide should be mixed in 20L of water?	How many days should be waited before harvesting?
White fly	Feeds on plant nutrients and transmit plant viruses		Malasol Dipel Yellow sticky traps.	35ml 20g	1 day

b. Disease Control

Name of disease	Impact on plants	Picture of damage caused	Control methods	Chemical dosage per 20l knapsack	Withdrawal period
Early blight	Circular brown spots appear on lower leaves and stems. Lower leaves turn yellow and fall. Brown spots also appear near stem of fruit. Severe infection cause all leaves to fall off exposing fruits to sunscald		- Destroy all crop remains after harvest - Fertilize and irrigate crop properly - Alternate the following pesticides in a spray program: Bravo, Cungfu, Amistar, Score and Ridomil	Preventative Bravo – 20ml Amistar – 20ml Score – 15ml Curable Ridomil – 50g Cungfu – 30 ml Copstar – 35ml	Bravo – 3 days Amistar – 7 days Score – 7 days Ridomil – 7 days Cungfu – 3 days Copstar – 3 days
Leaf spot	Causes dark spots on leaves with tiny black spots on the centre		Spray with Bravo or Amistar or score	Bravo – 20ml Amistar – 20ml Score – 15ml Copstar – 35ml	Bravo – 3 days Amistar – 7 days Score – 7 days Copstar – 3 days

Name of disease	Impact on plants	Picture of damage caused	Control methods	Chemical dosage per 20l knapsack	Withdrawal period
Bacterial wilt	Causes sudden wilting of plants without yellowing of leaves		- Avoid planting in contaminated soils - Choose resistant varieties - Plant tomatoes in well drained soils - Practice crop rotation - Remove and destroy infected plants		
Late Blight	Blue grey watersoaked spots on leaves which turn brown. Irregular greasy spots on fruits and stem. Dark greasy spots appear on fruit and enlarge until the whole fruit is affected		Spray with ridomil or bravo Destroy all plants after harvest	Ridomil – 50g Bravo – 20ml Cungfu – 30 ml Copstar – 35ml	Ridomil – 7 days Bravo – 3 days Cungfu – 3 days Copstar – 3 days

Name of disease	Impact on plants	Picture of damage caused	Control methods	Chemical dosage per 20l knapsack	Withdrawal period
Fusarium wilt	Attacks mature plants at the green fruiting stage causing plants to turn brown and leaves on one part of plant turn yellow. Whole plant eventually wilts		Plant in soil that does not have a history of disease Plant in soil that does not have nematodes Use seedlings that are free from disease	No registered chemicals for the cure.	
Powdery Mildew	Yellow spots form on upper leaf surface with a powdery covering on lower leaf surface. Severely affected leaves dry but do not drop from the plant.		Spray with amistar or copper oxychloride or dithane	Amistar – 20 ml Copper oxychloride – 100 g Dithane M45– 40g	Amistar – 3 days Copper oxychloride – 3 days Dithane M45– 7 days

12. Harvesting

- ✓ Fruits mature (green) at 70-80 days after transplanting and may take an extra 3-5 weeks to reach yellow or red color
- ✓ Harvesting continues with regular pickings at intervals of one to two weeks for a period of three months. Mature peppers are picked by hand and packed.
- ✓ At harvesting, fruits should be stored under shade to protect against direct sunlight.
- ✓ Expected yields are approximately 25-40 tons per hectare
- ✓ Peppers should not be washed and should not be harvested on rainy days

13. Post-harvest handling and storage

- ✓ Free from bacterial and fungal rot, pest damage, foreign matter
- ✓ Fresh and unhealed cracks not allowed
- ✓ Keep produce in a cool place that allows air to circulate and away from direct sun
- ✓ Field workers must cut nails short to avoid scratching produce
- ✓ Residue treatment not allowed
- ✓ Holes in peppers which expose interior are not allowed

POTATO

1. Background information

The potato (*Solanum tuberosum*) is the third most important food crop in the world, after wheat and rice. The plant is a member of the family *Solanaceae* and is closely related to other vegetables like tomatoes, eggplant, peppers etc. Potatoes are not roots, but specialized underground storage stems called tubers. The flesh of the potato consists of starch reserves and can be either white or yellow. The skin can be white, yellow, blue or pink, according to the variety.

2. Climatic requirements

- ✓ The potato thrives well when day temperatures are warm, but cool nights are needed for proper tuber formation, thus the potato is classified as a cool season crop.
- ✓ Optimum temperatures for tuber formation are between 18°C and 20°C.
- ✓ At temperatures above 32°C both tuber formation and yields are poor.
- ✓ Plants are very susceptible to frost damage, so planting dates should be chosen carefully.

3. Soil requirements

- ✓ Potatoes can be grown in a variety of soils, but do best in sandy loam soils with high organic matter content.
- ✓ Heavy clay soils produce good yields but badly shaped tubers and may cause difficulties at harvesting if soil is wet.
- ✓ Potatoes prefer a soil pH between 5.0 and 6.5.
- ✓ If lime is required, it should be applied earlier in the rotation, or at least 3 months before planting.
- ✓ Lime should not be applied at planting because it can cause a scab to the tubers.

4. Variety selection

- ✓ Choice of variety is determined by market requirements and planting season.
- ✓ Common varieties include Mondial, Sifra, Avalache and Fiana.

5. Land preparation

- ✓ Remove stones and plant remains before planting.
- ✓ Deep ploughing (30cm) followed by disking should be done to prevent crusting of the soil surface and produce a suitable bed when ridging.
- ✓ This is to allow ease of making ridges before and after planting.

6. Seed procurement

- ✓ Healthy seed should be sourced from a certified seed producer. Certified seed should have a certification tag.
- ✓ Good sprouts should be short, firm and green.
- ✓ Avoid buying over sprouted and shrunken seed as sprouts may easily get damaged and fall off the tuber.
- ✓ Small to medium sized seed should be planted whole while large sized seeds could be cut and then treated with a fungicide such as copper oxychloride.
- ✓ Seed requirement is 60-80 of 25kg bags per ha depending on seed size.

7. Planting

- ✓ Potatoes are normally planted on ridges.
- ✓ Planting spacing may vary depending on objective; whether the crop is for market or seed production.
- ✓ The standard spacing is 90cm between rows and 20cm – 30cm between plants.
- ✓ Planting depth is between 7 – 10cm under irrigation and 15cm on dry land production.
- ✓ Make sure to plant sprouted potatoes to attain a uniform crop stand.



8. Planting calendar

N.B. While highlighted below is a s a guide, farmers are therefore encouraged to consult with extension officer for ideal planting times.

	Months											
Area	JAN	FEB	MAR	APRL	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
Highveld	S	B	B	N	N	N	N	S	S	N	N	N
Middleveld	N	S	B	B	S	N	S	B	B	S	N	N
Lowveld	N	N	S	B	B	B	S	N	N	N	N	N

B-Best planting time, S-Suitable time, N- not Suitable

N.B. This is a guide and farmers are encouraged to consult with extension officer for ideal planting times.

9. Fertilizer application

- ✓ Fertilizer should be applied based on soil test results.
- ✓ Potatoes are heavy feeders; they require fairly large amounts of the major nutrients.
- ✓ The average fertilizer recommendation is 600kg/ha of 2:3:4 (39) for basal dressing and 150 kg/ha of LAN and 150kg KCl.
- ✓ Top dressing fertilizer can be broadcasted or applied in a band 5cm away from the plant at 4 – 6 weeks after emergence.
- ✓ Topdressing should be followed by earthing up which also cover applied fertilizer.
- ✓ Foliar fertilizer can be applied at 2 weeks interval to boost crop performance.

10. Irrigation

- ✓ Irrigation frequency is highly dependent on soil type; thus the farmer is encouraged to know their soil types.
- ✓ Irrigate regularly from planting to flowering and then irrigate more frequently from flowering to maturity.
- ✓ Ensure that irrigation does not expose tubers.
- ✓ Drip irrigation is highly recommended but overhead and furrow irrigation can also be used.
- ✓ Do not wait for the soil to be completely dry before irrigation as that can lead potato cracking.

11. Weed control

- ✓ Potatoes have shallow roots, thus are greatly affected by weed competition.
- ✓ Weeding can be done manually or mechanically.

- ✓ Paraquat and metribuzin can be used as pre-emergence herbicides applied at 3-5 days after emergency.

12. Earthing/heaping up

- ✓ Earthing up should be done when plants reach 10 – 15cm plant height to ensure that tubers are covered up.
- ✓ Do not cover more than half of the plant when heaping up.
- ✓ This is necessary to protect the developing tubers from greening which occurs as a result of light exposure.
- ✓ Heaping also protects potatoes from the potato tuber moth and late blight.
- ✓ Earthing up can be done manually or with the use of a specialized ridger.



13. Harvesting

- ✓ Cut off irrigation completely at maturity when leaves start drying off.
- ✓ Normally the haulms or tops of the potato crop are allowed to die off naturally, or they may be manually killed and removed 14 – 16 weeks after planting.
- ✓ Vine killing can also be done chemically through contact herbicide application.
- ✓ Avoid vine killing with systemic herbicides.
- ✓ Vine killing should be done 2 - 3 weeks before harvesting, this allows the tubers to set the skin.

- ✓ Harvest when 95% of the leaves have dried off.
- ✓ To verify if potatoes are mature, the skin should not peel off when rubbed by hand.
- ✓ Harvesting can be done manually (hand tools) or through a potato lifter.
- ✓ Do not harvest potatoes on wet conditions.



14. Yields

- ✓ Average yields are 15-20 tons per hectare for summer crops, and 24-27 tons per hectare for winter irrigated crops.
- ✓ Yields may go as high as 40 tons per hectare under good management practices.

15. Grading and Sorting

- ✓ The potatoes should be free from damage, blemishes, decay, insect infestation, discolouration, and be free from dirt / soil.
- ✓ They should be free from visible chemical residues and foreign matter.
- ✓ Potatoes should be sorted, graded and packed in different sizes ranging from small, medium, large and extra-large.

16. Post-harvest handling and Storage

- ✓ Potatoes are highly perishable, however, unwashed potato can store for longer at temperatures ranging between 10 – 20°C.
- ✓ They should be protected from direct sunlight.
- ✓ Tubers that are stored should be sound, clean and stored in a cool dark place to prevent greening and sprouting.

17 Pest and Disease Management

a. Disease Control

	Disease	Impact on crops	Picture of damage caused	Control	Dosage/ 20l	Withdrawal period
1	Early blight	Cause round dark brown lesions on leaves, sometimes surrounded by yellow color. Infected tubers develop round to irregular shaped lesions.		Planting healthy seed. Spray with Bravo, Amistar, copper oxychloride	Bravo – 20ml Amistar top – 20ml	
2	Late blight	Affects leaves and stems. Small light green circular to irregular water soaked spots appear on leaves. Dark grey to black lesions appear on stems		Planting healthy seed. Spray with Bravo and Amistar top. Spray with Mancozeb/Dithane	Bravo – 20ml Amistar top – 20ml	
3	Bacterial wilt	Cause wilting of plants even when soil is moist. Infected tubers show a brown ring when cut through.		Plant only certified seed potatoes. Remove and destroy infected plants. Avoid irrigation for more than six hours.		
4	Potato ring rot	Rot appears on the vascular ring of potato tuber. Dry cracks can be found on the surface of the tubers.		Plant healthy seed. Ensure proper management. Spray with fungicides before flowering.	Bravo – 20ml Amistar top – 20ml Dithane – 40g Ridomil – 100g	

	Disease	Impact on crops	Picture of damage caused	Control	Dosage/ 20l	Withdrawal period
5	Potato scab	Common scab: raised rough patches of skin on surface of tuber. Netted scab: brown netted scab on tuber surface. Powdery scab: irregular brown depressive lesion with remains of skin on the rim, containing masses of dusty brown spores on tuber surface.		Plant certified seed potato. Ensure adequate irrigation. Choose resistant cultivars Avoid planting immediately after liming.		
6	Potato leaf roll virus	Affected leaves show inward rolling, pale yellow, sometimes with red to blue-purple leaf margins.		Plant certified seed potato. Remove and burn affected plants. Apply aphicides to control virus vector insects	Aphicide, Malasol, Decis	
7	Potato virus Y	Affected leaves show mosaic and stipple-streak. Tubers show arc-shaped swellings initially, and then cause sunken lesions.		Plant certified seed potato. Remove and burn affected plants. Apply aphicides to control virus vector insects	Aphicide, Malasol, Decis	

b. Pest Control

	Name of pest	Impact on crops	Picture of damage caused by pest	Control	Dosage (in 20L knapsack sprayer)
1	Cutworm	- Cuts off stems of young plants during stand establishment -Later in the season, they feed on the plants -after tubers are formed, they feed on them as well		-Spray with one of the following insecticides a day or a week before planting. -Decis -Malasol -Cypermethrin -Control weeds before planting.	- Decis – 5ml - Malasol – 25ml - Cypermethrin – 20ml
2	Aphids	-Suck juices from young plant leaves. -This may result in stunted growth and deformed leaves. -Aphids also spread viruses to plant		- Spray with the following when seen: - Aphicide - Aphicide plus -Scout regularly from flowering until harvesting	- Aphicide – 35ml - Aphicide plus -20ml
3	Potato tuber moth	-Larvae bore into tubers. -Larvae may also feed on young leaves and stems		- Apply one of the following at first sign of moths and repeat at 2 week intervals - Decis - Malasol - Do not leave harvested tubers in the field over night.	Decis – 5ml

	Name of pest	Impact on crops	Picture of damage caused by pest	Control	Dosage (in 20L knapsack sprayer)
				Clean up crop remains after harvesting	
4	Red spider mite	Sucks plants leading to defoliation		Abamectin (Agromectin), Profenofos Pegasus	15ml 45ml 16ml
5	Leaf miner			Abamectin	15ml
6	Millipede	Millipedes tunnel into potato tubers		Good sanitation Avoid leaving debris and compost to prevent excessive accumulation of soil moisture	

SWEET POTATO

1. Background information

Sweet potatoes scientifically known as *Ipomoea batatas* are an excellent crop even for small scale farmers. They are a fairly drought tolerant crop, a valuable food, easy to grow and do not suffer much from pest and diseases. The growing of sweet potato should be encouraged as a useful starch supplement. It can be one of the most profitable crops grown in Eswatini.

2. Climatic requirements

- ✓ Sweet potatoes are of tropical origin and adapt well to warm climate.
- ✓ Sweet potatoes are cold sensitive thus they should be grown in frost free areas.
- ✓ Sweet potatoes grow best in temperatures ranging between 20 to 33°C.
- ✓ Rainfall is not critical but 650-900 mm is preferred.
- ✓ Sweet potato requires considerable amount of rain during the growth period (0–90 days) and a dry period (90–150 days) during root formation.

3. Soil requirements

- ✓ Sweet potato can be cultivated in a wide range of soils (pH 5.5-6.5).
- ✓ Well drained sandy loam soils are preferred and heavy clay soils should be avoided as they can retard root development.

4. Land Preparation

- ✓ The soil should be deep ploughed and disc cultivated to break up any large clods and provide enough loose soil for hilling of beds.
- ✓ Sweet potato must be planted on flat ridges which are 30cm high and 40 cm wide.
- ✓ Soils must be well drained and well aerated for a successful tuber growth.

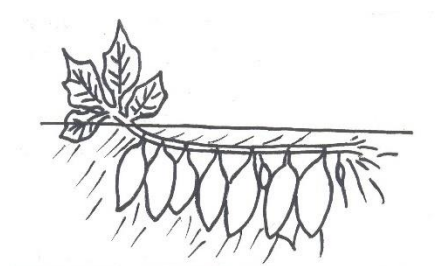
5. Vine Selection

- ✓ Vine tip cuttings of about 30-40cm long with approximately eight nodes are suitable for planting.

- ✓ The vine tip cuttings are found to be best to get higher tuber yield from sweet potato.
- ✓ Recurrent use of vines as planting material for more than 6 seasons may result in yield decrease and spread of diseases.

6. Planting

- ✓ Vines should be planted at a depth of 7 to 10 cm.
- ✓ 2/3 of the vine should be buried at an angle of 45 degrees.
- ✓ Plant vines at a spacing of 100cm between rows and 30 cm between plants.



7. Varieties

- ✓ Orange skin with orange flesh e.g., Beauregard
- ✓ White skin with white flesh e.g., Kenya white
- ✓ Red/purple skin with cream or white flesh e.g., AVRDC No.1 (Ligwalagwala)
- ✓ Variety selection should be determined by market requirement and growth season.

8. Cropping Calendar

	Months											
Area	JAN	FEB	MAR	APRL	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
Highveld	S	S	N	N	N	N	N	S	B	B	B	S
Middleveld	B	S	S	S	N	N	S	B	B	B	B	B
Lowveld	B	S	S	S	N	N	S	S	S	S	B	B

B: Best time for planting, S: Suitable time for planting, N: Not suitable

8. Irrigation

- ✓ Sweet potato requires sufficient soil moisture at the time planting to ensure proper sprouting and establishment of tubers
- ✓ Sweet potato requires 2mm of water per day
- ✓ All irrigation systems are suitable for sweet potato production

9. Fertilizer application

- ✓ Fertilizer should be applied based on soil analysis results.
- ✓ Basal fertilizer 350kg per hectare of 2:3:2(39) should be applied at planting.
- ✓ Top dress with 20kg urea + 100kg KCl per hectare at six weeks after planting.
- ✓ Excessive nitrogen application causes sweet potatoes to produce luxuriant vines and it also reduces the yield of the tubers.
- ✓ Band top dressing fertilizer at the side of the ridges then cover up with soil.

10. Weeding and hilling-up

- ✓ Sweet potato is a fast-growing crop and it covers up the soil quickly and suppresses most of the weeds.
- ✓ However, weeding may be necessary particularly in the early stages of growth.
- ✓ Hilling up needs to be done within 45 days after planting.

11. Pests and diseases

a. Pest Control

Name of Pest	Impact on Plants	Picture of Damage Caused	Control Method
Sweet potato weevil	Small and scattered feeding holes on the leaves. Internal portions of the roots are tunneled out. Rotting may occur and a strong rotten smell may be evident.		Management may be a combination of cultural practices and the trapping of weevils with a sex pheromone. Use clean cuttings.
Millipedes	Pierce and tunnel the tubers when harvesting is delayed.		
Sweet potato Hawk Moth (<i>Agrius convolvuliis</i>)	Large holes appear on leaves. Extensive defoliation occurs in the plant and plant may die.		Collect and destroy larvae. Plow fields soon after harvest to expose the pupae.

b. Disease Control

Name of Disease	Impact on Plants	Picture of Damage Caused	Control Method
Black Rot (<i>Ceratocystis finbriata</i>)	Disease spread usually occurs in the seedbed as the causal fungus grows from an infected potato into sprouts. The fungus will cause the potato to develop a bitter flavor.		Plant only, pathogen-free sweet potatoes vines. Maintain a two-year rotation.
Rhizopus Soft Rot (<i>Rhizopus spp.</i>)	Fungus causes a soft, spongy moist decay in storage or transit.		Avoid injuring sweet potatoes at harvest.
Southern Stem Rot (<i>Sclerotium rolfsii</i>)	Plants in beds wilt suddenly and then turn yellow to brown and die. Stems of sprouts will have brown lesions.		Maintain a two-year rotation.

Wilt/Stem Rot (<i>Fusarium oxysporum</i> f. sp. <i>batatas</i>)	The fungus in the vascular tissue causes the plant to wilt, yellow, and stunt. If the attack comes early in the season, the plant may die.		Select disease-free seed potatoes for slip production. Infested land should be rotated to other crops for 4-5 years. Use resistant varieties.
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13. Harvesting,

- ✓ Sweet potatoes should be ready to harvest between 3 and 6 months after planting.
- ✓ When harvesting, cut and remove the vines before digging.
- ✓ Be careful not to damage sweet potatoes, because the tubers have delicate skins that are very easily broken.
- ✓ Also avoid rough handling as the sweet potatoes are easily bruised.

14. Post-harvest handling and storage

- ✓ Sweet potatoes should be free from damage, blemishes, decay, insect infestation, and be free from dirt.
- ✓ Sweet potatoes should be sorted, graded and packed into different sizes.
- ✓ Unwashed sweet potato can store for longer at temperatures ranging between 10 – 20°C.
- ✓ Protect sweet potato from direct sunlight.

TOMATO

1. Background information

Tomato (*Solanum lycopersicon*) belongs to the Solanaceae family. Other related members include: potatoes, eggplant and peppers. They have a tap root system ranging from 30cm to 80cm deep.

2. Climatic requirements

- ✓ Tomato is a warm season crop that is sensitive to frost. For optimum vegetative growth, yield and fruit quality an average daily mean temperature of 18 to 24°C is key.
- ✓ Fruit set and quality are poor below 10°C and above 30°C. Hot dry winds cause excessive flower drop while continuous rain weather conditions, result in the occurrence and spread of foliar diseases.
- ✓ Therefore, it is recommended that tomatoes be grown in dry areas under irrigation.

Developmental stage	Minimum °C	Optimum °C	Maximum °C
Germination	11	16 – 29	34
Vegetative Growth	18	21 -24	32
Fruit set Day	10	14 -17	20
Night temperatures	18	19 -24	30

3. Soil requirements

- ✓ Tomato grows on well managed sandy loams and heavy clay loams, free of hard pan and best results are obtained in deep well drained loam (40 cm – 60cm deep).
- ✓ The soil should be rich in organic mater with pH value of 5.5 to 6.5.

4. Seedling selection

- ✓ Order your seedlings 6 - 8 weeks before planting from a **reputable** nursery.
- ✓ A good seedling is in the four- or five-leaf stage, vigorous and stocky.
- ✓ Seedling should have well developed root system and free from diseases.
- ✓ Procure hardened off seedlings

5. Varieties

- ✓ Variety selection should be dertemined by market requirement, season, growth habit and pest & disease resistance.
- ✓ Determinate : Star 9001, Star 9006, Star 9008, Star 9009, Disco, Degas, Sentinel

- ✓ Indeterminate: Trinity, Star 9037, Anna, Star 9081, Sensation
- ✓ Jam tomato: HTX 14, CHIBLI and star 9065.

6. Cropping Calendar

Area	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Highveld	B	S	N	N	N	N	N	S	B	B	B	S
Middleveld	S	B	B	S	S	S	S	B	B	B	S	S
Lowveld	N	S	B	B	S	S	B	B	S	N	N	N

B: Best time for planting, S: Suitable time for planting, N: Not suitable

7. Land preparation

- ✓ Plough at a depth of 30-40cm and apply the recommended amount of lime and manure.
- ✓ Harrow to incorporate soil amendments until it is well pulverized.
- ✓ Form flat ridges 15-20 cm high and furrows at least 1.5m apart.

8. Planting / transplanting

- ✓ Row spacing of not less than 1.5m and plant spacing between 40-45cm is recommended.
- ✓ Plant population is at least 16 000 per ha.
- ✓ Thoroughly mix basal fertilizer with soil and irrigate day before planting (plant on moist soil).
- ✓ Control cutworm before planting by spraying on the planting rows.
- ✓ Make the planting hole that is 2 times the size of the root ball of seedling.
- ✓ Insert the seedling in the hole such that the lower leaves (cotyledons) reaches soil surface.
- ✓ Early morning and late afternoon is the best time for transplanting or on a cloudy day.

9. Fertilizer application

- ✓ Fertilizer is applied based on soil analysis results.
- ✓ When using organic manure, make sure you apply it three months before planting to allow proper degradation and release of nutrients.
- ✓ General recommendations for fertilizer application are as follows:
- ✓ *Basal fertilizer:* Apply 600 kg (12 bags) 2:3:4 (39) at 1-2 weeks before or at planting.
- ✓ *Topdressing fertilizers:* Apply 100 kg (2 bags) LAN and 50 kg (1 bag) KCl per ha 4 weeks after planting and at 2-3 weeks intervals thereafter.

- ✓ Top dressing fertilizer should be applied on a wet soil and should be 10cm away from the plants.
- ✓ Boost with foliar fertilizers at two weeks interval if necessary.
- ✓ Apply 5:1:5 (45) at 200 kg/ha (4 bags) every after each heavy picking of fruits.

10. Irrigation

- ✓ It is important to supply sufficient water at critical times such as after sowing or transplanting.
- ✓ Drip irrigation is highly recommended but overhead and furrow irrigation can also be used.
- ✓ Irrigation requirements is determined by the soil types, method of irrigation, crop growth stage and the prevailing weather conditions.
- ✓ Critical stages include early establishment, flowering and fruit development.
- ✓ Irrigation should be done uniformly during development to reduce the risk of blossom end rot and fruit cracking.

11. Weed control

- ✓ Fields should be always free of weeds as they compete for nutrients, water and space with the crop.
- ✓ Plastic mulch under drip or organic mulching for other irrigation methods can help reduce weed infestation in the field.
- ✓ Carefully remove weeds mechanically or manually and avoid damaging roots as it may expose plants to soil borne diseases (wilt).

12. Trellising/Staking and pruning

- ✓ Most tomato varieties require trellising for disease prevention and good quality fruits.
- ✓ Staking should be done not later than 2 weeks from planting to avoid root damage and bacterial infection.
- ✓ Staking poles should be 1.7-2 m long, pitched 2-4 m apart and 60cm deep.
- ✓ When the tomatoes are 30 cm high, stretch double wires or twine on either side of the row at 30cm height and plants are sandwiched.
- ✓ Pruning is recommended for indeterminate varieties.
- ✓ Remove all lower leaves that have a potential to touch the ground and diseased leaves.



12. Pest and Disease Management

a. Disease Control

Name Of Disease	Impact On Plants	Picture Of Damage Caused	Control Method	Chemical Dosage Per 20l Knapsack	Withdrawal Period
Early blight	Circular brown spots appear on lower leaves and stems. Lower leaves turn yellow and fall. Brown spots also appear near stem of fruit. Severe infection cause all leaves to fall off exposing fruits to sunscald		Destroy all crop remains after harvest Fertilize and irrigate crop properly - Copper oxychloride - Bravo – 20ml - Amistar – 20ml - Score – 15ml - Ridomil – 50g - Cungfu – 30 ml - Copstar – 35ml - Mancozeb – 40g	100g 20ml 20ml 15ml 50g 30 ml 35ml 40g	3 days 3 days 7 days 7 days 7 days 3 days 3 days

Leaf spot	Causes dark spots on leaves with tiny black spots on the centre		- Bravo - Amistar - Score - Copstar(Copper hydroxide) - Xanbac	20ml 20ml 15ml 35ml 40ml	3 days 7 days 7 days 3 days
Bacterial wilt	Causes sudden wilting of plants without yellowing of leaves		Avoid planting in contaminated soils Choose resistant varieties Plant tomatoes in well drained soils Practice crop rotation Remove and destroy infected plants		
Bacterial spot	Causes small, dark greasy spots on leaves and stems of plants which eventually enlarge and dry to greyish brown. Raised spots appear on infected		- Bravo - Amistar - Score - kungfu	20ml 20ml 15ml 30ml	Bravo – 3 days Amistar – 7 days Score – 7 days kungfu – 30 ml

	fruits. Infected young fruits fall off from the plant		- Copstar - Xanbac Practise crop rotation Remove all weeds from edges of field.	35ml 40 ml	Copstar – 3 days
Late Blight	Blue grey watersoaked spots on leaves which turn brown. Irregular greasy spots on fruits and stem. Dark greasy spots appear on fruit and enlarge until the whole fruit is affected	 	- Ridomil - Bravo - Cungfu - Copstar - Mancozeb	50g 20ml 30 ml 35ml	Ridomil – 7 days Bravo – 3 days Kungfu – 3 days Copstar – 3 days
Fusarium wilt	Attacks mature plants at the green fruiting stage causing plants to turn brown and leaves on one part of plant turn yellow.		Plant in soil that does not have a history of disease Plant in soil that does not have nematodes	No registered chemicals for the cure.	

	Whole plant eventually wilts		Use seedlings that are free from disease		
Powdery Mildew	Yellow spots form on upper leaf surface with a powdery covering on lower leaf surface. Severely affected leaves dry but do not drop from the plant.		- Amistar - Copper oxychloride - Dithane M45 - Sulphur - Funginex	20 ml 100 g 40g 50g	Amistar – 3 days Copper oxychloride – 3 days Dithane M45– 7 days

b. Pest control

Name Of Pest	Impact On Plants	Picture Of Damage Caused	Control Methods	Chemical Dosage Per 20l Knapsack	Withdrawal Period
Cutworm	Feeds on seedlings at ground level causing them to fall.		- Decis - Cypermethrin - Karate	5ml 15ml 6ml	3 days 3 days
Leafminer	Eats through plant leaves leaving white trails. Leaves become weakened and heavy loss of leaves lead to sunscald		- Decis - Abamectin	5ml 15ml	3 days 3 days
Aphids	They form a cluster in plant leaves sucking plants juices resulting in stunted and distorted growth. They also spread diseases.		- Profenofos - Malasol - Decis - Keep fields weed free	100ml 25ml 5ml	4 days 2 days 3 days

Name Of Pest	Impact On Plants	Picture Of Damage Caused	Control Methods	Chemical Dosage Per 20l Knapsack	Withdrawal Period
Red spidermites	Feeds on underside of leaves causing pale spots on the surface of the leaves. Leaves later turn yellow and become bronze later dry. They also transmit diseases		- Profenofos - Abamectin	100ml 15ml	4 days 3 days
American Bollworm	Feeds on fruits		- Decis forte - Cypermethrin	5ml 15ml	3 days 3 days
Thrips	Suck plants juices from flowers and young leaves. Additional damages are malformation of leaves and dropping of flowers. Also transmit diseases.		- Profenofos - Malasol	100ml 25 ml	4 days 2 days

Name Of Pest	Impact On Plants	Picture Of Damage Caused	Control Methods	Chemical Dosage Per 20l Knapsack	Withdrawal Period
Nematodes	Cause swelling on plant roots. The swelling interfere with the plant ability to take up nutrients causing stunted growth.		Practise crop rotation	Plough deeply, weeds free, destroy infected plants. Grow tomatoes during cool season. Chemical control with fenamiphos 40 EC, carbofuran. Crop rotate with repellent crop (merigold). Maintain high level of organic matter in the soil	
White fly	Feed on plant juices leaving behind a sticky substance which becomes a host for sooty mould. The mould blocks sunlight from reaching the leaves. White fly spreads diseases.		Malasol Grab 500 EC Pegasus Confidor	35 ml 35ml 16ml 5 ml	1 day 3 days

Name Of Pest	Impact On Plants	Picture Of Damage Caused	Control Methods	Chemical Dosage Per 20l Knapsack	Withdrawal Period
Tuta Absoluta	Feeding damage is caused when the larvae penetrate the leaf and feed on the mesophyll parts of leaves. This results in irregular mines on the leaf surface, negatively affecting the photosynthetic capacity of the plant. Subsequently, damaged leaves shrivel, decreasing the photosynthetic capacity of the plant and potentially decreasing the plant's ability to defend itself from other harmful agents		Steward Ampligo	15 ml 20 ml	3 days 7 days

13. Post- harvest handling and storage

- ✓ Fruits mature 90 -120 days after planting.
- ✓ Expected yields is 20 – 30 tons.
- ✓ Harvested tomatoes should be free from bacterial and fungal rot, fresh crack not allowed, internal browning not allowed, water core not allowed, residue treatment not allowed, no shriveled tomato allowed, must be characteristic of variety, fresh, smooth, well shaped (typical of cultivar), no sunburn, blemishes and discoloration allowed, and must not yield to pressure when pressed with finger.

WATERMELON

1. BACKGROUND

Watermelon (*Citrullus lanatus*) belongs to the cucurbit's family (same family with pumpkins, cucumber, marrows, melon and gem squash). Watermelon is frost sensitive and monoecious (both male and female flowers are produced on the same plant). It is eaten as fruit in fruit salads or as desserts.

2. CLIMATIC REQUIREMENTS

- ✓ Watermelon is a warm-season crop and optimum germination temperature at temperatures of 27°C to 32°C with night temperatures not lower than 24°C
- ✓ Optimum growth temperatures at night are 18 – 20 °C and day 24 – 30 °C and for ripening 15 – 25°C

3. SOILS REQUIREMENTS

- ✓ Sandy soils are preferred but can be grown on a wide variety of soil
- ✓ The highest yield will generally be produced in well-drained sandy-loam soils
- ✓ Heavy clay soil, soil with obstructed drainage or very shallow soils should be avoided.
- ✓ Soil pH 5.8 – 6.2

4. VARIETY SELECTION

Watermelon should be selected based on market specifications, below are the list of recommended varieties for commercial purposes.

Varities

Diploid (seeded) varieties: Aksent, Amin 29, Star 9981, Crimson Sweet, Jubilee, Allsweet, Royal Sweet, Daytona

Triploid (seedless) varieties: Tiger F1, Fashion, Aramis, Gold finch, Taylor

5. PLANTING TIMES

Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Highveld	B	S	N	N	N	N	N	S	B	B	S	S
Middleveld	S	B	B	S	S	N	S	B	B	S	S	S
Lowveld	N	S	B	B	N	N	S	B	S	N	N	N

B – best time

S – suitable time

N – not suitable

N.B. This is a guide and farmers are encouraged to consult with extension officer for ideal planting times.

6. LAND PREPARATIONS

- ✓ Plough at a depth of 30-40cm and apply recommended amount of lime and manure
- ✓ Harrow to incorporate soil amendments until fine tilth.
- ✓ Form flat ridges or furrows at least 1.5m apart

7. PLANTING

- ✓ Ideal spacing: inter-row 150cm and in-row 90cm (7,400 plants/ha)
- ✓ Watermelons seeds are planted directly into the soil.
- ✓ Seeds may be soaked overnight to hasten the germination
- ✓ For an early season crop (spring), seedlings may be used to avoid rat attack
- ✓ Planting is done on raised beds 20 – 30 cm high and 40cm width for use under furrow irrigation
- ✓ Drip irrigation can also be used
- ✓ It is necessary to interplant triploid (seedless) watermelons with diploid watermelons as pollinator in order to achieve fruit set
- ✓ The triploid and diploid planting ratios may vary depending on the season
- ✓ Viable pollen only travels approximately 2m and more bees are necessary in order to achieve successful pollination
- ✓ It is advisable to plant triploid and diploid at a ratio of 2:1 in difficult pollination times (extreme weather conditions)
- ✓ When conditions are favourable, a ratio of 3:1 is sufficient

8. FERTILIZATION

- ✓ Watermelon has moderate nutrient requirements compared to other vegetable crops, and because of its deep rooting, it is efficient in extracting nutrients from the soil.

- ✓ Pre-plant soil analysis should be done at least 3 months prior to planting
- ✓ Watermelons are relatively sensitive to salts (alkaline pH) as this reduces yields by up to 50%
- ✓ Kraal manure should be applied at 10 – 15 tons/hectare and worked into the soil 3 - 4 weeks before planting
- ✓ Basal dressing: 2:3:2 (37) at 300kg to 400kg (6-8 bags) / ha, top dress with LAN at 200kg to 300kg (4-6 bags) / ha) and KCl 100kg (2bags) / ha after 30 days/ 4 weeks

OR

- ✓ Basal dressing 2:3:4 (39) at 300kg to 400kg (6-8 bags) / ha, top dress with LAN, 200kg to 300kg (4-6 bags) / ha
- ✓ Application of foliar fertilizer (V 12, Multi feed, Nutrient Feed) at 2 weeks intervals to boost crop yield at 750ml to 1,000ml / ha / 100L of water

9. IRRIGATION

- ✓ Water requirements will vary with soil types, season and growth stage
- ✓ Irrigate early in the morning or late in the afternoon (since there are high chances of transpiration)
- ✓ Water requirement critical at planting, vegetative and flowering stages
- ✓ Drip irrigation is recommended for water use efficiency, crop uniformity and reduce foliar disease incidence.

- ✓ After crop establishment, irrigation may be withheld for a period of 2 - 3 weeks to encourage deep rooting.
- ✓ Irrigation should be managed to minimize water stress throughout the fruit set and fruit sizing period.
- ✓ Water stress during early fruit development can result in small, misshapen fruits and the occurrence of blossom-end rot.
- ✓ As harvest time approaches, care must be taken to avoid large fluctuations in soil moisture content as heavy irrigation can result in fruit splitting.

10. WEED CONTROL

- ✓ The field should be always free from weeds as they compete for nutrients, water and space with planted crops
- ✓ Hand hoeing should be done before vining.
- ✓ Weeds should be controlled by hand pulling at later stages of crop growth.
- ✓ Plastic mulch is also recommended to control weeds.

11. PESTS AND DISEASE CONTROL

Pest/Disease	Picture of pest/disease	Symptoms	Recommended Chemicals	Application rate on 20 L water	Withdrawal period
Cutworm		Cutting of young plants at the base	Cypermethrin Decis Cutworm bait	20ml 5ml	

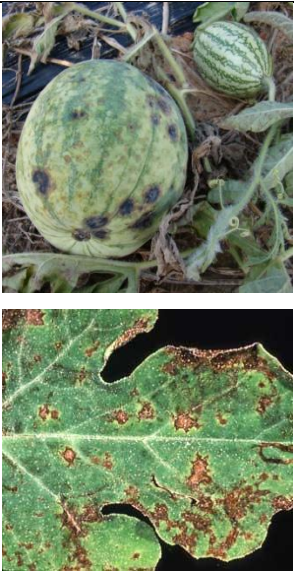
Pest/Disease	Picture of pest/disease	Symptoms	Recommended Chemicals	Application rate on 20 L water	Withdrawal period
Red spider mite		Tiny, yellow green to reddish brown spider like pest which spin silk threads for anchoring into the plants. Attacked leaves show white to yellow speckling.	Preventative Adequate irrigation, mulching to conserve moisture. -Sanitation Curative Abamectin	15 ml	7 days

Pest/Disease	Picture of pest/disease	Symptoms	Recommended Chemicals	Application rate on 20 L water	Withdrawal period
Leaf miner		Yellow scribbly lines in the leaves	Agromectin/ Makthromectin/ Abamectin	12 ml 12 ml 12 ml	7 days 7 days 7 days
Aphids		Clusters of tiny grey/white/green bugs on young leaves, distortion of young shoots, curling of leaves	Decis Cypermethrin Profenofos Aphicide plus	5 ml 20 ml 100 ml 100 ml	3 days 7 days 4 days 3 days

Pest/Disease	Picture of pest/disease	Symptoms	Recommended Chemicals	Application rate on 20 L water	Withdrawal period
Fruit fly		Fruits rot while young with visible larvae inside the fruit	Fruitcare GF 120 Mercaptothion Aviguard Fenthion - Use fruitfly traps	24 ml 700 ml 35 ml 35 ml	10 days 1 day 10 days 1 day

Pest/Disease	Picture of pest/disease	Symptoms	Recommended Chemicals	Application rate on 20 L water	Withdrawal period
Powdery Mildew		Infected leaves become covered with a white to grey powdery growth	Preventative Copper oxychloride Dithane M45 Curative Bravo, Amistar Ridomil gold Oscar	60g 50g 40 ml 50 ml 100g 15 ml	3 days 3 days 7 days 7 days 7 days 10 days

Pest/Disease	Picture of pest/disease	Symptoms	Recommended Chemicals	Application rate on 20 L water	Withdrawal period
Downy Mildew		Large, angular or blocky, yellow areas visible on the upper surface	Preventative Copper oxychloride Dithane M45, Curative Funginex, Bravo, Amistar Oscar	60g 50g 25 ml 40ml 50 ml 15 ml	3 days 3 days 1 days 7 days 7 days 10 days

Pest/Disease	Picture of pest/disease	Symptoms	Recommended Chemicals	Application rate on 20 L water	Withdrawal period
Anthracnose		Affected leaves have water-soaked lesions which enlarge and later turn brown and the dead tissue may fall out, creating holes in the leaves.	Preventative Copper oxychloride Dithane M45 Curative Bravo,	60g 40g 40ml	3 days 7 days 3 days

Pest/Disease	Picture of pest/disease	Symptoms	Recommended Chemicals	Application rate on 20 L water	Withdrawal period
Mosaic Virus		Dark green mosaic, vein clearing, yellowing leaves and hardening. Fruits become mottled and misshaped	Decis, Cypermethrin to control the vectors (aphids, thrips), remove and destroy affected plants.	5 ml 20 ml	3 days 7 days

Pest/Disease	Picture of pest/disease	Symptoms	Recommended Chemicals	Application rate on 20 L water	Withdrawal period
Gummy stem		Irregular brown to black blotches appear between leaf veins, gradually expanding and resulting in the death of the affected foliage. Older stems at the crown near a leaf petiole or	Avoid irregular irrigation Use Copper oxychloride, Dithane		

Pest/Disease	Picture of pest/disease	Symptoms	Recommended Chemicals	Application rate on 20 L water	Withdrawal period
		tendrils split and ooze.			

11. Physiological disorders

Name of physiological disorder	Picture of physiological disorder	Symptom	Prevention or correction measure
Fruit cracking		Cracking or splitting of the shell	Avoid irregular irrigation Proper variety selection Never apply nitrogen at final stages of fruit development

12. Harvesting and Handling

Harvesting

- ✓ Harvesting may begin from 3 to 4 months after planting depending on the variety.
- ✓ Harvest when the tendrils have changed colour from green to brown
- ✓ Harvest when the ground spots have changed from white to light yellow
- ✓ When you thumb the fruit, a metallic ringing sound indicate immaturity and a more muffled sound or dull sound indicate maturity.
- ✓ Flesh colour should have reached a mid-pink to deep pink red and must be firm and crispy
- ✓ Harvesting should be done in the early morning as fruit respire much more rapidly and lead to over-ripe fruit on delivery.
- ✓ Cut the stem about 3 to 4 cm long and do not pull fruit from the vine.
- ✓ Regular sanitation of knives and pruning scissors is essential.
- ✓ Expected yield should be 25 – 50 tons

Post-harvest practices

- ✓ Harvested fruit should be kept under shade and transported to the packhouse within the shortest possible time to prevent the fruit temperature from rising and minimize moisture loss.

Sorting and grading

- ✓ Watermelons are sorted to remove insect damage, blossom-end rot and cracked discoloured and those without stocks.
- ✓ Sorting is also done according to size, small, medium and large according to variety
- ✓ Watermelons are packed in large sturdy fibre board containers.

Storage

- ✓ Watermelons are not adapted to long term storage and varies from variety to variety.
- ✓ Storage for more than 2 weeks triggers a loss in flesh, crispiness and flavour.
- ✓ If exposed to warmer temperature under storage, the flesh colour tends to intensify.
- ✓ Watermelon flesh will tend to lose its red colour if held too long at temperature below 10°C.
- ✓ They should be held at 10 – 15°C and 90% relative humidity.

SPINACH

1. Background Information

Spinach (*Spinacia oleracea*) do well in cool weather and it is tolerant to frost. The Highveld of Eswatini is ideal for production in summer and in winter in the Lowveld. In the Middleveld it can be grown all year-round. Spinach is a biennial plant with large dark green leaves. The large, glossy, crisp leaves can grow to 37 cm long and 25 cm wide. Some cultivars are upright with broad leaf stalk, whilst some have long, light green leaves and thin stalks. The plant has a moderate deep root system. The roots are hard and woody. Common names: Swiss chard, spinach beet, silver beet, seakale beet, chard, leaf beet, also referred to as 'spinach' by most people in Southern Africa.

2 Climatic Requirements

- ✓ Spinach is a cool season crop that grows best at temperatures ranging from 8 to 24 °C.
- ✓ It is half-hardy and can withstand light frosts. Prolonged exposure to temperatures less than 5°C will induce seed production (bolting), usually in spring. During hot weather above 32°C, leaves remain small and are of poor quality.

3 Soil requirements

- ✓ Spinach can grow in a variety of soils, most preferable well drained, with high organic matter.
- ✓ Sandy loam to loamy soils are ideal.
- ✓ Spinach is particularly sensitive to poorly drained soil conditions and to acid soils.
- ✓ Optimum soil pH should be between 6 and 6.5

4 Variety Selection

Spinach Selection is widely influenced by market preference.

Spinach varieties

Swiss Chard: Ford Hook Giant, Star 1801, Green wave

Mustard (bitter): Florida

Chinese spinach

Planting Calendar

Climatic region	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	N
Highveld	S	S	S	S	B	B	B	B	B	S	S
Middleveld	S	B	B	B	B	B	B	S	S	S	S
Lowveld	N	N	S	B	B	B	B	S	S	N	N

B – Best planting time

S- Suitable planting time

N

– Time not suitable for planting

Seeds/seedlings Preparation

- ✓ Spinach can be grown as seedlings and seed.
- ✓ **For seedlings**; Prepare or order seedlings 4-6 weeks before the planting date
- ✓ **For seeds**; it is broadcasted or sown on wider beds. Irrigate lightly a day before sowing.
- ✓ Cover the seeds with fine soil and keep the soil moist until the seeds have germinated with the seedlings emerging.

Use quality seed with a good germination percentage

5 Land Preparation

- ✓ 1st ploughing to bury crop residues and allow to decompose for 3-4 weeks.
- ✓ The land should be well prepared with 2nd ploughing 15 to 20 cm deep to break up clods.
- ✓ Small clods and crumbly soil improve water penetration and be less likely to crust after heavy rain

- ✓ Apply organic manure or compost, harrowing and ridging to improve water drainage (25-30t/ha kraal manure is applied before planting).
- ✓ In high rainfall areas plant on the ridges in summer and in furrows in winter

6 Planting

- ✓ Plant spacing; between rows is 45cm – 50cm, 15-20cm between plants and 2.5cm deep.
- ✓ Plant population; 250 000 – 280 000 plants/ha.
- ✓ For direct planting spray with insecticides to control cutworm after the first irrigation from planting.
- ✓ Irrigate in advance so that the seedling is placed in moist soil.
- ✓ Planting on raised beds are the best way to produce spinach.
- ✓ Late afternoon is the best time for transplanting

Seeding Rate

- ✓ Generally transplanting is being practiced.
- ✓ Seeding rate should be 7 to 9 kg/ha for direct seeding.

- ✓ Direct seed planter can also be recommended.
- ✓ Thin plant after 2-3 weeks after emergence on moist soils

7 Fertilizer Application

NB: Fertilizer recommendations should be based on soil analyses and never use chicken, pig, and feedlot manure

- ✓ Liming to fix acidity, if recommended by tests results, should be done 3 – 4 months before planting.
- ✓ It should be noted that this serves as a general recommendation.
- ✓ For Basal application; 150 kg/ha of 2:3:2 (37) fertilizer (3 bags) in bands and mix soil with fertilizer and irrigate a week before planting
- ✓ For top dressing application; At 3 weeks after planting side dress with 200kg/ha (4 bags) LAN and apply every after heavy harvesting.

8 Irrigation

- ✓ Spinach prefers moist soils to encourage production of new leaves.
- ✓ Moisture fluctuations will cause leaves to become tough and leaf development will also be slow.

- ✓ Mulch around the plant will help to conserve soil moisture.
- ✓ Furrow irrigation is suitable where there is sufficient water while drip irrigation is ideal where water is scarce.
- ✓ Overhead irrigation encourages spread of diseases

9 Weed control

- ✓ Weeds compete with spinach for space, light, water and nutritional resources in the soil, particularly during the early part of the season. They can reduce yield if left unchecked.
- ✓ Perennial weeds should be eliminated prior to planting spinach. Regular cultivating prevents weeds competing with spinach.
- ✓ Hoe weeding is recommended for small scale producers and selective herbicides are more ideal for control in larger-scale and commercial plantings.

Pest and Disease Management

GUIDE FOR PEST CONTROL IN SPINACH

Name of pest	What impact does it have on plants	Picture of damage caused by pest	How can it be controlled	How much pesticide should be mixed in 20L of water	Withdrawal Period
Cutworm	Cut seedlings		Spray with one of the following a day or week before planting - Decis - Malasol - Cypermethrin	Decis – 5ml Malasol – 35ml Cypermethrin – 20ml	Decis - 2 days Malasol - 7 days Cypermethrin - 7 days
Aphids	They suck juices from the plant resulting in stunted growth.		Spray with malasol or agromectin at first sign of pest infestation.	Agromectin – 12 ml Malasol – 35 ml	Agromectin – 7 days Malasol – 7 days

			Remove weeds on edges of field.		
Leaf miner	Larvae mines leaves producing discoloured patches on leaves		Leafminer may be controlled chemically by applying registered chemicals – spray with Agromectin	Agromectin/Abamectin/ Makhromectin– 15ml Steward-	Agromectin - 3 days
Snails			Snail surrender Beer traps, crushed egg shells or river sand		

GUIDE FOR DISEASE CONTROL IN SPINACH

Name of disease	What impact does it have on plants	Picture of disease	How can it be controlled	How much pesticide should be mixed in 20L water	Withdrawal Period
Cercospora Leaf spot	Infected plants develop light grey spots with a darker outline		Sanitation-destroying infected debris by deep ploughing after harvesting. Also practice crop rotation.	-Bravo – 40ml (Preventative) -Ridomil – 20g (Control)	Bravo – 3 days Ridomil – 7 days

Name of disease	What impact does it have on plants	Picture of disease	How can it be controlled	How much pesticide should be mixed in 20L water	Withdrawal Period
Leaf spot	Symptoms initially appear as brown spots, turning grey with reddish purple borders at a later stage.		Spray with a registered chemical. Copper oxychloride, Dithane, Bravo, Ridomil	Copper oxychloride – 60g (Preventative) Dithane – 40g (Preventative) Bravo – 40ml (Preventative) Ridomil – 20g (Control)	Copper oxychloride – 3 days Dithane – 7 days Bravo – 3 days Ridomil – 7 days

Name of disease	What impact does it have on plants	Picture of disease	How can it be controlled	How much pesticide should be mixed in 20L water	Withdrawal Period
Curly top	-Infection is characterized by clearing of veins in the leaves and leaf curling with sharp protuberances from the veins on the leaf undersides. -Leaves may be thickened and somewhat brittle.		-Rotating the crop from one location to another in subsequent years and using good cultural practices such as proper watering and good fertility will help in controlling this disease.	-Agromectin – 12 ml -Malasol – 35 ml	Agromectin – 7 days Malasol – 7 days

Name of disease	What impact does it have on plants	Picture of disease	How can it be controlled	How much pesticide should be mixed in 20L water	Withdrawal Period
			-Resistant varieties may be planted		

Name of disease	What impact does it have on plants	Picture of disease	How can it be controlled	How much pesticide should be mixed in 20L water	Withdrawal Period
Powdery and downy Mildew	-Downey mildew: Chlorotic lesions form on leaves. -Powdery mildew: leaves turn yellow and dry out.		-Pick leaves regularly to avoid them getting old. -Follow the proper plant spacing. -Use resistant varieties.	Bravo – 40ml (Preventative) Ridomil – 20g (Control) Downey mildew: Use Funginex	Bravo – 3 days Ridomil – 7 days

*1 level tablespoon is approximately 15g.

10 Harvesting

- ✓ Start harvesting at 4 - 5 weeks after transplanting.
- ✓ Care should be taken not to damage the leaves whilst harvesting the product.
- ✓ Avoid damaging the growing points (new shoots) when harvesting.
- ✓ Harvest leaves that are free from snails, damages, deformities and are clean.
- ✓ A week is required for regrowth before the second harvest to yield adequate volume.
- ✓ After harvesting the produce should be kept under shade to remove field heat.
- ✓ Yield is 15 ton/ha.
- ✓ Bunching ties should not be too tight as crushed or split petioles may lead to decay.
- ✓ Freezer burn will be initiated at 0 - 3° C, so if stored, store in a refrigerator not a freezer.
- ✓ Freezing injury results in water-soaked lesions followed by rapid decay associated with soft rot bacteria.
- ✓ It has a short shelf life so it has to be harvested and taken to the market the same day.

LETTUCE

1. Background information

Lettuce (*Lactuca sativa*) is a cool season crop. Lettuce originated in parts of Asia, but the Egyptians were the first to domesticate it. It is tolerant to light frost. Lettuce is a sensitive plant and the leaves are easily damaged. Lettuce wilt easily because of their high-water content,. Lettuce is a very nutritious food source and generally the darker the leaf the more the nutritional value.

2. Climatic requirements

Lettuce germinates at a temperature range of 15-20°C. Germination may be compromised when temperatures are above 25°C. All lettuce varieties require cool weather and do best when temperatures are between 15-22°C. When temperatures reach 28°C and higher, it causes the plant to mature and go to seed faster before the head and leaves are ready to be harvested.

3. Soil requirements

Lettuce requires well drained sandy loamy soils with a pH of 6-7. Soils should have a high organic composition.

4. Variety selection

There are 4 main types of lettuce with few cultivars each;

- ✓ Iceberg (Crisphead)lettuce: The most popular type of lettuce grown in South Africa. Its leaves are tightly packed together producing a firm head with crispy leaves.
Commander, great lakes, summer gold,
- ✓ Butterhead lettuce: these types of lettuce produce loose heads, with a butter texture with soft waxy leaves and a mild flavour. All year round, bostol,
- ✓ Romaine or Cos lettuce: This type of lettuce has a more upright or oval head shape with dark outer leaves with a crispy texture, considered to be more nutritious than crisphead lettuce. Varieties include: green forest, green towers, plato
- ✓ Loose leaf lettuce: This type of lettuce does not form heads, the leaves are joined at the stem. Varieties include oak leaf, lolla rossa, bionda, Multi leaf and green leaf.

5. Planting calendar

Growth period for varieties (5-6 weeks)

Climatic region	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Highveld	S	S	S	S	B	B	B	B	B	S	S	S
Middleveld	S	B	B	B	B	B	B	S	S	S	S	S
Lowveld	N	N	S	B	B	B	B	S	S	N	N	N

6. Plant Population and Spacing

For Crisphead cultivars a population of approximately 45 000 – 60 000 plants per hectare is recommended. Higher plant densities result in smaller the head size. A larger head size usually commands a higher price. Speciality (baby) lettuces can be grown at much higher densities than Crisphead cultivars.

Recommended spacing: 60cm x 30cm (53 000 plants/ha)

7. Land preparation

- ✓ 1st ploughing to bury crop residues and allow to decompose for 3-4 weeks.
- ✓ The land should be well prepared with 2nd ploughing 15 to 20 cm deep to break up clods.
- ✓ Small clods and crumbly soil improve water penetration and be less likely to crust after heavy rain
- ✓ Apply organic manure or compost, harrowing and ridging to improve water drainage (25-30t/ha kraal manure is applied before planting).
- ✓ In high rainfall areas plant on the ridges in summer and in furrows in winter

8. Fertilizer application

Apply fertilizer according to test result recommendations.

- ✓ Basal fertilizer, apply 300 kg of 2:3:4 (30) per hectare.
- ✓ For large head development apply 250 kg of L.A.N after 3 weeks close to the plant.

- ✓ Over application of nitrogen may result in increased susceptibility of the crop to various diseases or disorders.
- ✓ Applying foliar fertilizers every two weeks is recommended for good yields

9. Transplanting Seedlings

- ✓ Seedlings should be transplanted between 4 - 6 weeks after sowing.
- ✓ Seedlings must be transplanted at the correct depth in a little planting hole that has been made in the ground prior to planting.
- ✓ If the seedlings are forced into the ground, without a hole being prepared for them to be inserted into, the root system will be damaged and the plant will experience stress resulting in poor yield.
- ✓ Once the seedling is placed inside the hole the area should be firmed so that sufficient contact is made between the seedling and the soil.
- ✓ When planting seedlings a choice can be made between the square method and the staggered method of planting.
- ✓ The staggered method is more advantageous as there is less competition between plants compared to the square method where plants are directly opposite each other, thus maximizing competition.

10. Irrigation

- ✓ Lettuce has a shallow root system and as such requires frequent but lighter irrigations.
- ✓ The roots penetrate the soil to a depth of only 30 cm.
- ✓ Water should be applied throughout the growing period and reduced when the heads become full.
- ✓ A water shortage tends to promote bolting.
- ✓ Irrigate every two days in winter and daily during summer hot months.

11. Weed control

- ✓ Weeds are controlled mechanically, manually or chemically.
- ✓ Mechanical weed control can only be practised before planting because of close spacings.
- ✓ Weeds are removed by hand hoeing or pulling between plants in the rows.

Name of pest	What impact does it have on plants	Picture of damage caused by pest	How can it be controlled	How much pesticide should be mixed in 20L of water	Withdrawal Period
Cutworm	Cut seedlings		Spray with one of the following a day or week before planting -Decis -Malasol -Cypermethrin	-Decis – 5ml -Malasol – 35ml -Cypermethrin – 20ml	-Decis - 2 days -Malasol - 7 days -Cypermethrin - 7 days
Aphids	They suck juices from the plant resulting in stunted growth.		Spray with malasol or agromectin at first sign of pest infestation. Remove weeds on edges of field.	-Agromectin – 12 ml -Malasol – 35 ml	-Agromectin – 7 days -Malasol – 7 days
White fly	Larvae mines leaves producing discoloured patches on leaves		Leafminer may be controlled chemically by applying registered chemicals – spray with Agromectin	-Agromectin/ Abamectin/ Makhromectin– 15ml Steward-	-Agromectin - 3 days

Snails	Foliage has holes when the snails feed.		Snail surrender Beer traps, crushed egg shells or river sand		
American bollworm	The larvae feeds on the developing head until they reach maturity.		Cypermethrin Decis Forte Malasol	Decis – 5ml Malasol – 35ml Cypermethrin – 20ml	
Thrips	Puncture and suck the plant sap. Punctured leaves take on a silvery appearance that eventually turns to brown scarring.		Cypermethrin Decis Forte Malasol	Decis – 5ml Malasol – 35ml Cypermethrin – 20ml	

Guide for disease control in lettuce

Name of disease	What impact does it have on plants	Picture of disease	How can it be controlled	How much pesticide should be mixed in 20L water	Withdrawal Period
Fusarium wilt	It is a soil borne disease which causes yellowing and necrosis of leaves as well as stunting and wilting of plants.		Remove and dispose of affected plants. Clean farm equipment.		
Grey mold	Wilting and collapse of young seedlings, followed by a wet decay and necrosis		Avoid injury to the plant. Avoid overhead irrigation. Minimize crop residues in the field.	Copper oxychloride – 60g Dithane – 40g Bravo – 40ml Ridomil – 20g	Copper oxychloride – 3 days Dithane – 7 days Bravo – 3 days Ridomil – 3 days

Powdery and downy Mildew	Downey mildew: Chlorotic lesions form on leaves. Powdery mildew: leaves turn yellow and dry out. (a powdery growth on the upper and lower leaves of the plant).		Use Bravo as a preventative measure. Use neem as an organic fungicide. Use resistant varieties.	Bravo – 40ml Ridomil – 20g Downey mildew: Use Funginex	Bravo – 3 days Ridomil – 3 days
Pythium diseases	General wilting and collapse of lettuce foliage.		Use Bravo as a preventative fungicide.	Copper oxychloride – 60g Dithane – 40g Bravo – 40ml Ridomil – 20g	Copper oxychloride – 3 days Dithane – 7 days Bravo – 3 days Ridomil – 3 days

Ring spot (anthracnose)	Necrotic rings and ring-like pattern on middle leaves of plants.				
Sclerotinia	Sclerotinia fungus will cause a brown, soft decay that		The stem and leaves must not be in contact with the soil.		

12. Harvesting and post-harvest management

- ✓ Crisp head lettuce is harvested when the heads are firm.
- ✓ When harvesting, care must be taken not to damage the wrapper leaves.
- ✓ The loose-leaf types are harvested when the leaves have acquired the required size.
- ✓ As a highly perishable crop, lettuce needs to be harvested early in the day when temperatures are still cool.
- ✓ During harvesting, lettuce with snails and damaged should be sorted.
- ✓ After harvesting store in a cool dry place and refrigerate if possible.
- ✓ Avoid harvesting when plants are wet or after rains as wet foliage is more conducive to rotting.
- ✓ Crisp head lettuce is marketed loose and packed in units of 12 in a carton for the fresh market or as pre packs in a punnet.
- ✓ Loose leaf lettuce is often cut and further processed as part of a prepack salad mix.