

FARM MANAGEMENT HANDBOOK

SECTION C: CROP PRODUCTION

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Agronomy

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CHAPTER 1: FIELD CROPS

Coffee (Coffee arabica)

Varieties

Variety	Growth habit	characteristics
SL28	Normal open growth	Drought hardy and yields high quality
SL34	Normal open growth	Yields good quality coffee and more suitable to high altitude
K7	Normal open growth and more vegetative	Less susceptible to several races of leaf rust and tolerant to dry conditions
caturra	Dwarf and more dense and vegetative in cooler areas	Drought tolerant and produces lower quality bean.
<i>Mundo Nova</i>	open growth habit	Cross from Mundo Nova. Late maturing and can tolerate drought conditions
<i>Catimor</i>	Semi dwarf	A variety resistant to coffee berry disease.
<i>Catuai Yellow</i>	Semi dwarf	Cross from Mundo Nova. Late maturing and can tolerate drought conditions

Other promising varieties include SL9, KE20, KP432, K33, 119/4, 900/10.

.Length of season

- First crop is obtained 2½ to 3 years after planting.
- One can harvest 5 to 6 crops depending on the growth rate. Rejuvenation is needed after first crop cycle of 7 to 8 years. Second cycle may last 6-8 years.
- The maximum desirable extension of the crop is up to the 3rd cycle.

Stages of growth

Plant seed to emergency	Up to 6 weeks
Emergency to transplanting	6- 8 weeks
Nursery growing before transplanting	10- 12 months
Field transplanting to first flowering	14 –20 months (for fly crop)
Subsequent flowering between September and November each year	1 or 2 main flowering plus 1 or 2 minor flowerings
Flowering to ripe cherry	6 to 8 months
Period of harvest	2 to 6 months

Nursery practices

Seed:

- Coffee seed is provided by approved seed producers during July to November each year.
- Quantity of seed required depends on population required. Aim for 5 000 plants/ha allowing for 20% discard.

Site Selection

- Warm situation, frost free, sheltered from wind, convenient for supervision and adequate clean water is the best site.

Soil

- Light textures, fertile and friable. Avoid capping, saline, vlei type soils. Heavier, compacting type soils may require mixing up with up to 50% river sand and manure pH (CaCl₂) 4,5 to 5,5)
- Choose eelworm free, virgin soil. Potting soil should be screened through a coarse sieve.

Fertilizer

- Compound S (6:17:6) mixed with potting soil at 3kg/m³ soil.
- Composted coffee pulp manure at rate of 9% by weight is a good substitute for fertilizer (used in pot filling).

Plant containers

- Open-end polythene sleeves or containers with closed but perforated bottoms.
- Dimensions; lay flat 15-20cm wide and 20cm long (height).

Pot filling

- Funnel with spout same size as the diameter of the sleeve/pot fitted over the sleeve.
- Soil is poured into the sleeve via the funnel.
- Output per labour day is 500 – 800.

Time of sowing

- Normally September to December, in cooler areas it is better to sow earlier in the season (September to October).

Nursery construction

- Requires wiring, roof two metres high. Cover sides and roof with a thin layer of thatch grass or reeds to provide 50% shade. Leave bottom side open to allow cold air drainage.
- Alternative shading of a narrow shade ban about 1m above each bed of pots. Beds of pots dimension 1,5m wide.

Seed Treatment

- Against *Furasium Lateritrium* 1g Benomyl 50 WP per 1kg coffee seed.
- Treat 1 to 5 kg of seed at a time by shaking in a half filled plastic bag.
- Plant directly afterwards.

Nursery Management

Sowing

- Sow 2 to 3 seeds per pot about 5cm apart. Place seed 0,5cm below surface flat side down.
Mulch the pots.

Watering

- Watering every 2 or 3 days until germination.
- Watering techniques include handled hose with fine oblong rose head, overhead micro jet pattern, and perforated pipe.

Mulching

- Place fine fibrous mulch to a depth of 5cm over pots until emergency.
- Thin out the mulch and finally remove it when cotyledons emerge.

				Or Comp J AN M/P	200		150	60 60	150	150 60	60 60	150
4 th and subsequent years	270	90	560	SSP	300		190	150		150		130
				AN	200							
				MoP	100	100	100	100	100	100		
				Or Comp J	225	225	225	225	225	225	225	225

General fertiliser recommendations for dry land coffee

Plantation age			Time of application kg/ha								
	Suggested fert	Annual rate kg/ha	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
Year of planting	Comp S Comp J AN	300 200 45				300		50	50	50	50
2 nd year	Comp J AN	600 50	75	75	75	75	75	75	75	75	
3 rd year and following ratooning	Comp J AN KCl	800 126 110	100	100	100	100	100	63 55			100 62 55
4 th and subsequent years	Comp J	1200	160	160	160	160	160	160	160	160	160
	Comp J	1800	225	225	225	225	225	225	225	225	225
	Comp J	1125	225	225	225	225	225				
	AN	300							100	100	100
	KCl	225							75	75	75

For diagnostic Norms of leaf analysis of the 3rd or 4th pair leaves refer to the table below

Nutrient	Optimum range
Nitrogen %	2,5 –3,0
Phosphorus %	0,10 –0,20
Potassium %	1,50 – 2,50
Sulphur %	0,10 –0,20
Calcium	0,70 – 1,50
Magnesium %	0,20 –0,40
Iron ppm	50 –150
Manganese ppm	50 –150
Copper ppm	5 –40
Zinc ppm	10 –30
Boron ppm	30-50

- The correct use of these optimum ranges will ensure that nutrition is not a limiting factor in coffee production.
- The ranges can also be used to identify excessive use of fertilizer.

Liming

Required below pH levels of 4, 6. The ideal pH range is 4, 8 to 5, 3 CaCl₂.

Trace elements

Boron- foliar spray 0, 5% solution Solubor, toxic in excess.

Zinc Oxide at rate 3kg/ha with a spreader.

Soil and leaf sampling

- Soil samples should be taken well before growing coffee seed to ensure that correct amounts of lime or phosphates are added to the soil.

- Leaf samples are taken once the trees start cropping in August or September before fertiliser for the next season is applied.

Instructions for taking leaf samples

Method of sampling

1. Sample the 3rd and 4th pair of leaves from a bearing branch. Do not count the terminal pair of leaves if they are less than 2 cm long. Wherever possible take perfect disease free leaves.
2. Take 4 pairs of leaves from each tree and sample at least 10 trees (minimum 80 leaves).
3. Sampled leaves should be immediately placed in a polythene bag and labelled on the outside.
4. Soil samples should be taken at the same time.

Irrigation requirements

Overhead irrigation systems are no longer recommended in coffee production. Under tree irrigation which includes drip offer the following advantages over overhead systems used in coffee:

- Less water is required especially during early establishment period. Savings of between 30 to 40% have been achieved without any detrimental effects to crop.
- Low power required.
- The effects of poor quality irrigation water e.g. bicarbonate are reduced.
- Fungicides and insecticides are not washed of the leaf surface by irrigation.
- Weed growth in the inter row is reduced hence the cost of weed control are reduced.
- Compaction caused by pickers and droplet action from irrigation is reduced.
- Very difficult to change hence during drought years coffee is likely to receive the irrigation when it needs it most.
- Will not cause drainage problems as with overhead irrigation on certain soils.
- Costs of scheme are lower in the long run.
- There is a lower rate of disease incidences.

Estimates of Et/Eo ratio for mature coffee plantation

Over tree sprinkler irrigation	Et/EO
a) Mulched inter row	0.65
b) Clean cultivated inter rows	0.75
Under tree basin or trickle	
a) Mulched inter row	0.45
b) Clean cultivated inter rows	0.60
Microject irrigation	
a) Mulched inter row	0.60
b) Clean cultivated inter rows	0.65

Estimates of water requirements

Northern Mashonaland	Over tree sprinkler		Under tree drip basin or trickle	
	Net (mm)	Gross (mm)	Net (mm)	Gross (mm)
April	100	115	60	70
May	90	100	60	70

June	85	95	55	60
July	100	115	70	75
August	130	150	90	95
September	185	200	115	130
October	210	250	130	150
November	150	170	100	110
Total	1050	1195	680	760
Chipinge				
April	80	95	50	55
May	70	85	45	50
June	105	120	70	80
July	75	85	50	55
August	100	115	60	65
September				
October	150	170	95	110
November	135	150	85	100
	715	820	455	515

Estimated of the irrigation system capability required to prevent excessive water stress in the peak use period

Northern Mashonaland	mm/month	
	Net	Gross
Overhead, tree sprinkler irrigation		
a) Mulched	180	220
b) Clean cultivated	215	250
Under tree basin drip or trickle irrigation		
a) Mulched	140	155
b) Clean cultivated	160	175
Chipinge		
Overhead, tree sprinkler irrigation		
a) Mulched	140	155
b) Clean cultivated	160	190
Under tree basin drip or trickle irrigation		
a) Mulched	100	110
b) Clean cultivated	100	120

Mulching

- Large yields advents have been obtained from mulching coffee on a field scale without shade.

Physical benefits

- Reduces soil erosion.
- Improves soil moisture aeration.
- Builds up on soil fertility.
- Suppress weeds.
- Reduces soil temperature.

Disadvantages

- Harbours pests.

- Increases frosts hazards.
- Increases fire hazards.

Mulching requirements

- Mature coffee – complete 38/ha/year alternate row 19t/ha/year.

Mulching materials

- Indigenous grasslands- 6t/ha, crop residues soya bean, wheat, and maize cultivated, Napier grass in well-fertilised fields – 50- 75 t/ha.

Intercropping

- Coffee can be intercropped with beans, tobacco, potatoes, and maize but in the first year.

Pruning and rejuvenating

- Free growth of the tree is recommended. Regular pruning is not advisable on 2 accounts
 - I. Very often results in poor productivity
 - II. Some of the techniques e.g. single stem system of pruning is labour intensive
- Any part cut must be sprayed or smeared with Captafol to prevent infection by *Fusarium*.

Rejuvenation

- Coffee will be out of production in 1 to 2 years
- Rejuvenation should be done when crop expectation for the coming season is low
- For best results rejuvenation should be done during September and not later than October.
- In cooler areas it can be done after 6 crops where as in warmer areas it may be after 4 crops.

Forms of rejuvenation

1. Parrot perched all primary branches cut back to leave 2 or 3 nodes from main stem
2. Ratoon tree back to 50cm above ground level
3. Capped trees- usually done to 2m above ground level and then ratooned 2 years later.

The suckers, which subsequently develop, should be progressively thinned out to leave the required number.

Weed control

Way of controlling weeds

- Hand cultivation / hand pulling
- Mechanical cultivation
- Mulching (mulching suppress weeds)
- Herbicides

Recommended Herbicides and application rates

Trade name (technical name)	Target weeds	Appl rate /ha	time	Remarks
Gramoxone	Most annual	1.5 – 4litres/ha	Post emergent	Spray directly at any

(Paraquate weeds)	weeds			contact with foliage. Avoid contact with foliage and immature bark. Apply as often as possible in clean water
Simazine 80wp (Simazine)	Most annual weeds	1.5- 3,5 kg/ha	Pre emergent	Any time after transplanting. Mix with paraquat for a post emergent effect.
Gardoprim 80wp (Teruthylazine)	Annual weeds	3.5-4.5litres	Pre emergent	As above
Gardomil 500fw (Teruthylazine + metalochlor)	Annual weed	5- 6.5litres/ha	Pre emergent	Anytime after transplanting
Gesapax (Ametryn weeds)	Annual weeds	6.5litres	Pre emergent, early emergent	Not for young coffee, do not apply in drip zone and split application may be done 6weeks apart
Ametryn 80wp (Ametryn500)	Annual weeds	4kg		
Diuron 80wp (Diuron weeds)	Annual weeds	2-5.0kg	Pre emergent, post emergent	Not for young coffee, avoid drip zone up to 2 years
Dual 720 ec (Metalochlor)	Annual grasses	1.5-2.5litres	Pre emergent	Anytime after suppression of transplanting
Fusillade Roundup (Glyphosate)	All annual and perennial weeds	1.6litres	Post emergent	Avoid all crop contact. No wetter needed. Best results in low volume high concentration clean water essential
MSMA 80wp	Nustedges, some annual broad leaved weeds and grasses	3litres	Anytime after transplanting	Spot spray as required in hot dry weather. Avoid all crop contact. 2 applications needed for nustedges control
Basafapon Dowpon Gramevin (Dalapon)	Many grasses including couch, spear start grass and kikuyu	5.5 –7.7kg	Post emergent	Not in root zone for crops under 2 years. Repeat after 12weeks if necessary
Cotoran 80wp (Fluometuron)	Many annual broad leaved weeds and some grasses		Pre emergent, residual	Apply to clean soil

Coffee Pest identification

Pest	Damage and symptoms	Identification in field	When to treat
Leaf miner very common and important	Leaf miners causes irregular brown blotches and sever leaf drop	Eggs: almost invisible Larvae: white caterpillar 4-8mm long Pupa: H shaped white cocoon around 6mm long on underside of leaves Adult: small white moth about 3mm long. Nocturnal. Best seen towards evening by disturbing 'skirts' of trees	About a week after appearance of moth. However if active mines are seen spray immediately
Antestia Bug Quite common Very important	Blackening and shedding of flower beds and immature berries.	Eggs: White. In groups of about 12 in underside of leaf. Nymphs: 5 nymphal stages representing adults	When average population of adults plus nymphs exceeds

	Rotting of beans	but more rounded and without functional wings. Adult: Shield shaped bug. About 6.5mm long. Brown and white and orange markings.	1 per tree.
Common Looper Not common Very serious	Leaf-eating causing severe reduction in leaf area.	Eggs: Singly on underside of leaf. Sea urchin shape. Pale yellow-green with fine radial ribs \pm 0.6mm. Larva: Green looper without hair, up to 35mm, 3 pairs thoracic legs and 3 pairs abdominal legs. White line through spiracles and series of white lines running down the back.	When insignificant numbers of eggs are noted – the larger caterpillars are very difficult to control.
Red Tortix Green Tortix Occasional pest	Feeds on green berries, leaves and shoot tips and can act as a tip borer. Causes berry damage and drop. Makes silken nests between young leaves or within dusters of flowers or cherries.	Eggs: Yellow orange flattered. Groups of \pm 230 on upper surface, overlapping like fish scales. Egg masses about 12mm wide. Larvae: Green tortix is green with black head and thoracic shield. Red tortix is reddish brown with dark brown stripes. Skeletonizes leaf within nest. Cherries bored out and lined with silk.	Spray at first indication. Spot spraying may be sufficient. Important to control before larva enters berries.
Berry moth occasional pest	Berry clusters webbed together. One or more brown, dry and hollow.	Eggs: Scale like. Single. On or near green berries. Larva: Reddish caterpillar up to 12mm. Bores into berries near stalk and joins cluster of berries together with web while feeding.	Soon after main flowering if indicated, re-spray 5-6 weeks later.
Systates weevil Common Lesser pest	Adult beetles feed on leaf margins causing characteristic indentations.	Adult: Black beetle, flightless, snorted about 12mm long. Feed at night and shelter during day.	When nurseries or young transplants are affected. Not normal to treat older trees.
White borer Insidious Serious locally	Yellowing of foliage – often part of tree only – Wood shavings extruding from stem base where bark is severely channelled or ring barked. Round emergence holes of adults in lower trunk.	Eggs: inserted beneath bark, about 45cm from ground. Larva: Bore under the bark downwards finally penetrating the wood from below ground. Makes a chamber within base of trunk. Pupa: Pupation 2-4 months within stem chamber. Adult: Beetles \pm 30mm emerge from exit hole. Brown with white markings. Male has very long antennae.	On routine basis, just prior to start of seasonal rains.
Stinging Caterpillar lesser pest	Leaf eating Stinging field workers.	Eggs: In groups. Overlapping like tiles. On lower leaf surface. Greenish yellow. Larvae: Attractively coloured. Young larvae mainly white becoming green. Covered with tubercles bearing stinging 'hairs'.	Before significant of leaf area or if irritation to workers becomes real nuisance.
Jelly Grub	Leaf eating	Eggs: White, scale like, laid singly on both sides of leaf. Larva: Slug like, bluish-green up to 13mm long.	Before significant loss of leaf area.
Mealy Bug Occasional Serious	Mealy white masses of insects. Prefer belly clusters and shady interior. Associated with honeydew and sooty mould.	Nymphs/Adults. 3 Nymphal stages. Starts of with no wax, flat oval and light brown with 6 legs. When in feeding position develops characteristic wax covering.	Preventive: Annual stem banding and lifting 'skirts'. Curative. Immediate spraying if observed.

Pest Control

Chemical control

Pest	Chemical	Code	% Formulation	Dosage/100 litres of water or as stated	Days	Application directions
Antestia	Fenthion	Red	60ec	85ml	21	Full cover spray prior to blossoming. Repeat after 3 weeks if necessary Spray prior to main loom period and repeat after 14 days.
			50ec	75ml		
			60sc	80ml	30	
	Methyl	Purple	90sp	30g	28	Apply 1000L/Ha
	Parathion	Purple	25wp	100g	21	Full cover spray prior to blossoming or when pest is noticed. Repeat after 14 days if necessary.
		Purple	50ec	50ml	21	
	Trichlorfon	Amber	95sp	100g	10	Full cover spray prior to blossoming or when pest is noticed. Repeat after 14 days if necessary.
Ants	Chlordane	Amber	30ec	40ml	-	Brush on to trunk of tree
Berry Moth	Parathion	Purple	25wp	180g	21	Full cover spray
		Purple	50ec	90ml	21	
Black borer Black/ brown Scale	Mineral oil	Green	80ec	3L		Drench spray on young green stage. Repeat after one month. Do not apply in low humidity or at temperatures above 30°C. Do not mix with sulphur formulation.
Cut-worm	Endosulfan	Purple	35mo	850ml		Add 100kg low grade maize meal. Moisten with water to obtain a crubly texture. Apply in the late afternoon or evening. Do not apply to tobacco lands or cotton.
		Purple	50wp	625g		
	Phoxim	Green	0.5b	10kg/Ha		Overall application. Spread evenly. Not for use on tobacco lands or cotton. Band 20-50mm on planting row. Not for use on tobacco lands or cotton.
	Trichlofon	Amber	25sp	5kg/Ha 60g/100L	10	Apply 20kg in meal 25L h20 apply before plant emergence.

Fruit fly	Trichlofon	Amber	95sp	50g	10	Apply 9kg sugar. Apply as a course spray when flowers appear. Repeat at 7 day intervals and after rain at 40 l/ha.		
Giant Looper	Endosulfan	Purple	35mo	33l/100l	21	Full cover spray adding Molasses. Apply 1000l/ha.		
	Endosulfan	Purple	50wp	2kg/100l	21			
	Methomyl	purple	90sp	620g	28			
Green tortix Moth larvae	Trichlofon	Amber	95sp	200-2 000g/ha	10	Full cover spray		
Jelly Grub	Parathion	Purple	25wp	900g	21	Full cover spray		
		Purple	50ec	450ml	21	Full cover spray		
Leaf Miner	Deltamethrin	Green	2.5ec	300ml		Full cover spray Apply in 1000-2000L water/ha when moths or eggs first seen and repeat 28 days later. Max. 2 pyreths/season do not use in June, July & Aug.		
				300ml				
	Disulfoton	Purple	2.5	5	30g/m of bush	90	Apply to base of tree work in lightly with shallow cultivation. Up to 60g/tree.	
	Fenitrothion	purple	10g		15g/m of bush height/cora.			
Monocrotophos	Red	60ec		1.9l	30	Full cover spray at 1 100/ha. Repeat after 21 days if necessary.		
Purple	40wsc			1.2l	30	Apply at 500ml/tree adding 10ml wetting agent/100:1 mix		
purple	60sc			80ml	30	Add 10ml wetting agent. Apply 500ml/tree.		
	Fernvalerate	Amber	20ec	300ml	28	Full cover spray when adults 1 st noticed. Repeat 28 days later. 2 sprays per season June, July 7 Aug.		
	Parathion	Purple	25wp	1.8kg	21	Full cover spray prior to blossoming at 1 000l/ha. Repeat at 14 day intervals if necessary.		
		Purple	50ec	900ml	21			
	trichlofon	Amber	95sp	1kg	10	Full cover spray		
Mealy bug	Diazinon Carbofuron	Red	20ec	160ml	21	Apply as spot spray when pest is seen.		
	Aldicarb Fernvalerate	Purple	15g	Granules	115	10g per cover full cover spray maximum of 2 sprays per season.		
		Amber	20ec	15ml	21			
Red Tortix Moth larvae	Trichlofon	Amber	95sp	200g up to max. 2kg/ha.	10	Full cover spray		

Leaf Rust	Copper oxychloride Bayfidan	Amber	50wp	400ga 38g	Repeat at 14 day intervals if the disease is severe otherwise 21-28 day intervals. Before onset of the rains. Make shallow trench along drip line and put in granules then cover back with soil.
Rust	Propiconazole	Red	50ec	1 l/ha	Full cover spray
Cercispora leaf and berry blight	Copper oxychloride	Amber	50wp	400g	Repeat at 14 day intervals if disease is severe otherwise 21-28 day intervals
Coffee Berry Disease	Copper oxychloride	Amber		3kg captafol + 2.5 kg copper oxychloride per ha.	Full cover spray. spray mix the two chemicals and repeat application every 4 weeks.

Table showing an intergrated programme for the control of Fusarium bark disease and leaf rust in different areas of Zimbabwe. Also included are recommendations for seedlings and seed-bearers.

Area	Chemical	Month of application							
		Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Eastern Districts	Copper oxychloride	.	.	.	.	.	.	.	.
	captafol	.	.	.	.	.	.	.	.
	Triadimefon(rust only)	.	.	The two sprays should be six weeks apart and only applied if there is evidence of leaf rust in August.					
Other areas	Copper oxychloride	.	.	.	.	.	.	.	.
	captafol			When fusarium becomes established it would be advisable to apply captafol in December, January and February instead of copper oxychloride.					
	Triadimefon (rust only)			Two sprays six weeks apart are required when an outbreak of rust occurs.					
				* Continue at six weekly intervals if rust is still prevalent.					
Material	Chemical	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Seed-Bearers	Captafol	.	.	.	.	.	.	.	.
Seedlings	Captafol	Current seed is produced in areas where no rust is present. 80% wp applied at weekly intervals using 200g product in 100 litres of water.							

Picking, Harvesting

Coffee berries ripen progressively and may be reaped at intervals of seven to fifteen days. Berries must be reaped evenly at the correct stage of ripening to permit uniform pulping fermentation and finally quality, bright red for red varieties, deep yellow for yellow varieties.

Ripening outputs depend on

1. methods of reaping
2. rate of ripening
3. no. cherries/kg

Example of ripening output based on an acceptable labour efficiency level (75%) and an average of 500 cherries per kilogram.

Method	Type of Reaping	Output per reaper per hour
Pocket on reaper	Minor reaping (fly pickings)) less than 1kg cherries per bush.	5.5kg
Pocket on reaper	Intermediate reapings, between 1-2kg of cherries per bush.	10.0kg
Pocket on reaper	Main reaping more than 2kg of cherries per bush.	18.5kg

Crop Processing and Drying

Considerations for sitting a pulper:

- direction-NNW- to obtain longest period of winter sun
- slope – four to six percent is ideal
- water – clean, near source
- central to operations
- supervision
- power source
- clean surrounds to avoid tainting of parchment

Stages of processing

- cherry grade – 1 Size – screen , 2density – water(siphon tank
- Pulp – remove skin – drum or disc pulper. One pulping disc =0.75 – 1.0 tonne of cherry per hour. See paragraph on ratio by mass.
- Pre grade – size screen, density in water
- Ferment or aqua pulp – remove mucilage
- Wash by hand or coffee pump; remove fermented mucilage only.
- soak – under water which gives a bleaching action
- channel grade based on density of coffee in water
- dry parchment – sun or artificial
- store

Approximate water requirements of four different pulperies

Type of pulper	Water required per tonne of Green Coffee
Pre and post washing channel	100m ³
Aagard with no re-circulation	75m ³
Aagard with partial recirculation	50m ³
Aagard with full re-circulation	25m ³

Drying Coffee

- Sun drying on table racks
Drying table dimension is 1.2m wide by 36m long at waist height.
Approx table requirement for area yielding 2.5t/ha, drying period 20 days, 25mm deep on tables per ha.
- Artificial Drying Stages in Approx. bean moisture content

Coffee Drying		%
i.	skin drying remove all free water	49 – 45
ii.	Main drying Whitish colour beans	44 – 30

Soft black	29 – 22
Medium black	21 – 16
Hard black	15 – 12
Grey blue fully dried	12 – 10
Yellow green over dry	10

Drying Procedure

- Skin dry as soon as possible by higher rate of drying – ventilation rate 0.25m³/sec/m² of dryer bed area through a bed depth of 150mm of fully wet parchment at an air temperature of 35° C for a period of not exceeding 24 hours.
- To soft black stage (22 percent moisture), dry at a slower rate as moisture is drawn from within the bean. Advantageous to allow ‘rest’ periods between ventilation, e.g. at drying at 30°C for 12 hours and ‘rest’ for 12 hours.
- Final stages of drying to hard black stage (11.5 percent moisture) continual drying at 35 – 38°C.

Approximate ratio by mass of forms of coffee:

Cherry :	Parchment :	Green Coffee
5 :	1 :	0.8
or 6.25 :	1.25 :	1.0

Considerable variation can occur in these ratios depending on the season, the age of coffee and the state of the coffee plantation.

Description of the forms of coffee:

- Cherry Coffee – as picked ripe red from the tree:
- M’Buni Coffee – dried with skin, despatched to GMB at 10.5 percent moisture content.
- Parchment Coffee – After pulping, fermenting and drying, despatched by farmer to the GMB in bags 40 to 50kg at 11.5 percent moisture.
- Green Coffee – After hulling at the meal to remove parchment and silver skin. Repacked in 60kg bags after classification of green coffee. In milling there could be a 17 – 20 percent weight loss.

Marketing

Standards of Quality and Moisture content:

- Washed coffee and green coffee – 11.5 percent max. moisture
- Unwashed coffee – 10.5 percent maximum moisture
- No extraneous, deleterious or poisonous matter unfit for human consumption.
No extraneous matter liable to damage machinery

Standards of Classification

Packed in sacks of natural or synthetic fibres, not exceeding:

- green coffee – 80kg
- washed coffee – 43kg
- unwashed coffee – 30kg

- Delivery loads of different lots of coffee should be clearly marked to distinguish each lot for separate classification.
- All sacks should be marked in figures of no less than 70mm in height with producers number (GMB).
- Sacks should be sewn (do not use lugs) at the mouth in one of the following ways:

Hand sown with either:

- Good quality double jute twine, or
- Double cotton-rayon twine of minimum breaking strain of 150Newtons, or
- Single cotton-rayon of minimum breaking strain of 300 Newtons. Sew straight with 25mm stitches across mouth of the sack and leave 100mm free twine at each without knots.

Machine sewn with cotton/rayon/nylon thread-breaking strain of minimum 80Newtons.

GMB Depots for Coffee: Chipinge, Mutare, Banket.

Standards of Classification and Quality

Green coffee

Class	3	4	5	6	7	9
Maximum number of block coffee beans	Nil	Nil	Nil	Nil	Nil	Nil
Maximum number of diseased coffee-beans	10	20	30	40	-	-
Maximum number of foxy coffee-beans	Nil	5	10	15	20	-
Maximum number of insect damaged coffee-beans	Nil	5	10	15	30	-
Maximum number of pulper-nipped coffee-beans	Nil	5	5	10	-	-
Maximum number of stinker coffee-beans	Nil	Nil	3	5	-	-
Maximum number of unhulled coffee-beans	Nil	Nil	Nil	Nil	Nil	12

'Maximum number' refers to the number of appropriate coffee-beans found in working sample.

Levy

At present 1 percent of sales.

Milling

Payment to the grower is based on the mass of net green coffee. The milling losses, from parchment form to green coffee, vary between 17 and 20 percent. Milling losses between M'Buni form and green coffee are between 47 and 50 percent.

Insurance

See chapter on insurance in Finance section of this handbook. There is no insurance against frost damage.

Labour and Fuel Requirements

Operations	Labour days per ha of coffee (not nursery area)
i. Nursery	
Digging holes for uprights placing	1.08
Uprights and refilling holes, place cross members and wire for shade support (L)	0.01
Treat uprights (L)	0.15
Cut materials for nursery shade (L)	0.60
Transport shade material (D + 6)	0.15
Cut materials for nursery shade (L)	0.60
Transport shade material (D + 6)	0.15
Load trailer with shed material (D + 6)	0.15
Unload trailer, place shed material (L)	3.15
Digging potting material, loading trailer, transport and unload (D + 3)	12.50 (one final plant per pot)
Filling pots 10mm ³ of potting mix/ha of coffee grown (L)	
Planting seeds (L)	17.60
Unloading (L)	4.40
Sorting coffee plants in nursery prior to planting (L)	4.62
Water, weeding, thinning, spraying etc.	9.13
(One permanent worker in nursery for twelve months (L)	

L = General worker

D = Driver

D+3 = Driver and three general workers

F = Foreman

Labour and Fuel Requirements

Operations	Labour days per ha of coffee	
	Standard varieties	Dwarf varieties
ii. Field Operations		
a) Plantation		
Marking plant stations (Checkrow basis) (L)	1.50	1.65
Digging planting holes (F + 12)	30.61	60.02
Refilling planting holes (F + 12)	2.68	5.25
Applying pre-planting fertilizer (F + 12)	1.27	1.94
Mix fertilizer and topsoil (F + 12)	1.25	2.45
Trailer loading with young plants, unloading and planting (F + 12)	11.87	15.87
Cut mulch material (F + 6)	5.12	5.12
Load trailer with mulch material, transport unload (D + 6)	8.75	8.75
Spread mulch in land (L)	6.20	12.76
Topdressing year 1	12.85	12.85
Year 2	9.64	9.44
Year 3(SSP. AN.M/P) cost of	8.80	9.21
	8.80	9.21
	16.10	17.23
	12.00	12.84

Alternative year 3 (J. AN. M/P) fertilizer Year 4(SSP. AN. M/P) Alternative year 4(J) method Spraying: (With herbicide extreme care is needed. Different spray tanks essential for insecticides and herbicides) Cultivation (L) (budget for three occasions) Apply Dysiston (for minor control. 1 x per season before rains) (F + 12) – For covering see cultivation. (b) Coffee pulper, allow three permanent workers for 100 days in 180 day picking season (F + 2)	2.66/occasion (4-6 sprays/annum)	2.66/occasion (4-6 sprays/annum)
	3.66/occasion	3.66/occasion
	1.58/occasion	1.54/occasion
	7.5	
Sorting coffee on drying tables (F + 12)	35.0	
Harvesting * (pocket on reaper) Fly picking, less than 1kg per bush Intermediate picking 1-2kg per bush Main picking more than 2kg per bush	5.5kg/reaper/hour 10.0kg/reaper/hour 18.5kg/reaper/hour	
Transporting harvested coffee from land to pulper (D) Ploughing (D) (actual)	2.5labour days/ha 0.29	
Discing (D) (actual)	0.14	

- For budgetary purposes allow 150ld/ha for mature crop.

Labour and fuel requirements

Operations related to Napier fodder production	Labour days per ha of:	
	Napier Fodder	Coffee
Cut Napier fodder for seed purposes (L) (Australia Knife)	1.89	0.95
Remove tops (L)	1.50	0.75
Remove leaves (L)	1.20	0.60
Stack for transport (L)	2.99	1.50
Cut sets (L)	2.04	1.02
Apply fertilizer (F + 12)	2.45	1.23
Cover fertilizer (L)	2.41	1.21
Plant Napier Fodder (L)	4.06	2.03
Cover sets (L)	3.14	1.57
Cultivation (Land) (L) (F +12)	5.6/occasion	2.8/occasion
Top-dress (Land) (L)	2.45/occasion	1.23/occasion
Cutting Napier Fodder for mulch	10.24	5.12

Moisture stress to induce flowering												
Fertilizing				top	dress				foliar			
Mulching												
Scouting for insects and diseases												
Driedrin banding Stem												
Spraying for control of leaf rust and bark disease												
	Aug	Sep.	Oct.	Nov.	Dec.	Jan	Feb	Mar	Apr	May	Jun.	Jul.

* Optional depending on the system of tree management chosen.

Cotton

Climatic Requirements

- Cotton requires a growing season of 180 frost-free days (6-7 months).
- The crop requires high temperatures, long sunshine hours and an average rainfall of 600-700mm
- It is mainly grown in Midlands, Mashonaland and Manicaland provinces between altitudes of 600-1200m and in the South-East Lowveld at the altitudes at 300-600m..

Soil Requirements

- Cotton does better on well drained, fertile soils with a high water holding capacity and unrestricted depth.
- The optimal pH for cotton production is 5.3-5.5.

Fertilisers

General fertiliser recommendations are :

	GOOD SOIL	MEDIUM SOIL	POOR SOIL
N Lowveld Irrigated	80kg/ha	100kg/ha	120kg/ha
N Middle veld Irrigated	60kg./ha	80kg/ha	100kg/ha
N Middle veld Dry land	40kg/ha	60kg/ha	80kg/ha
P ₂ O ₅ Irrigated	40kg/ha	60kg/ha	80kg/ha
Dryland	20kg/ha	40kg/ha	60kg/ha
K ₂ O Irrigated	-	40kg/ha	80kg/ha
Dryland	6	30kg/ha	60kg/ha

- The recommended basal fertiliser is Cottonfert/ Compound L which contains boron for fruiting.
 - Ammonium nitrate or urea is used for top dressing. The top dressing can be given as a single dressing or split into two given at 4 weeks and 8 weeks after planting..

The amounts of fertiliser applied would be:

On good soils 200 kg (4 bags) of Compound L per ha
 100 kg (2 bags) of AN. “

One medium soils 300 kg (6 bags) of Compound L “
 150 kg (3 bags) of AN. “

Varieties

- SZ9314 is the variety that is being grown in most of the cotton growing areas.

Land Preparation

- Good land preparation provides a fine tilth.

Planting

- The earliest planting dates are controlled by legislation for the control of the pink bollworm.
- The earliest dates are 5 and 20 October for the south-east Lowveld and the remainder of the country respectively.
- For dry land cotton, planting should be done after the first effective rains.

Spacing

- Interrow and intrarow spacing of 100 cm and 30 cm respectively.
- Under marginal growing conditions, the interrow and intra row spacing 90 cm and 20 cm respectively.

Seed Rate

- It is recommended that a seed rate of 20-25 kg/ha on light soils and 35-40 kg/ha on heavy soil.
- Place 4-8 seeds together in the planting hole and cover to a depth of 20 mm.

Gap Filling

- Gap filling should be within 3 to 5 days after emergence.

Thinning

- This is done five days after emergence and must be completed by the time the crop is three weeks old.

Weed Control

It is important that the cotton crop is kept weed free during the critical stages of its growth cycle:

- first eight weeks after crop emergence since the crop is most vulnerable to competition at this stage due to its slow growth rate
- During the picking stage.

The three methods for weed control are:

- Hand hoeing
- Mechanical methods
- Herbicides: The table below gives herbicides which can be used on cotton, and of three types:

Pre – planting herbicides	These are incorporated into the top few millimetres of the soil before the crop is planted.
Planting herbicides	These are incorporated into the seedbed at planting time.
Post emergence herbicides	These are sprayed on while the crop is growing; they kill the weeds without harming the crop.

HERBICIDES

Product	Trade Name	Time of Application	Weeds Controlled	Notes
Trifluralin	Treflan, Trif	Pre-planting : incorporate 50-100mm immediately.	Mainly monocots; Incl. S.g.*	Rain or irrigation not required to activate
Nitalin	Planavin	Pre-planting; incorporate only into top 37,5mm of soil	Mainly monocots; Incl. S.g.* and some dicot	Rain or irrigation not required to activate.
Fluometuron	Cotoran 80W	At planting	Most. Usually not S.G.*	Not on sand, residual effects
Fluometuron	Cotoran 80W	At planting	Most. Usually not S.G.*	Not on sand. Residual effects
M.S.M.A.	Rasna Panther Juce	Directed spray Post emergent	Most weeds in seedling stage	May have to repeat. Do not apply after 1 st blooms

- S.g. – Shamva grass

DISEASES

Bacterial Blight or Black Arm Diseases:

- This causes dark green marks on the stems and leaves of the plant, and is sometimes called Angular Leaf Spot.
- This is controlled by using resistant varieties.

Verticillium Wilt:

- This is a fungal disease favoured by cool weather

Fusarium Wilt :

- This is a fungal disease which attacks the plant through wounds in the root system.

PESTS:

Aphids:

- Small green bugs which are experienced when weather conditions are hot and dry.

Jassids:

- Small, yellowish-green bugs Their presence is indicated by the initial yellowing of leaves then reddening (hopper burn) with a slight curling of the leaf edges.

Whiteflies:

- These produce honeydew which causes open cotton to become black.
- Whiteflies are a mid to late season pest.

Red Spider Mite:

- Tiny red dots found on the underside of leaves.
- Leaves mottle on upper surface of leaf, later turn yellow and are shed.

Cotton Stainer:

- Insects are orange-red and black in colour, with long stylet mouth.
- Feeds on seeds and stains lint of immature bolls. The stainers produce a fungus that stains the lint such that it develops a yellow colour.
- Cotton stainers are a late season pest.

Lygus Beetle:

- Very small brown bugs capable.
- Young leaves show perforations and a ragged edge.

Pink Bollworm:

- The pink coloured larvae attacks the green boll and feeds on the immature seeds.
- Prevention is achieved by destroying all trash from the crop and having a close season of at least 2 months (66 days).

Red Boll worm:

- Larva has rose – red arrow head markings.
- Internal feeder in bud or bolls; growing points attacked.
- Treat with 85% W.P. Carbaryl.

American Bollworm:

- Larva has dark band along back.

Spiny Bollworm:

- Fleshy tubercles are seen along backs and sparse coarse hairs on all segments.
- It will attack buds and bolls besides tip-boring.

Leaf Eater Caterpillars:

- Perforation of the leaves indicate damage done by these caterpillars.

PEST CONTROL

Scouting is very important in cotton pest control as it ensures the effective use of pesticides and timely control of the pests.

CHEMICAL CONTROL

- The pesticides used in cotton include conventional insecticides (Carbaryl, Thiodan and Larvin), synthetic parathyroid and acaricides.

SPRAYING

Spraying can be done by:

- knapsack sprayer
- tractor sprayer, using a boom with 7 or 9 nozzles
- aerial spraying by fixed wing aircraft or helicopter.
- To calculate the amount of the concentrate liquid to use the following formula can be used :

Amount of spray required x % concentration of active ingredient x 160 = Amount of concentrate required. The outputs of various spraying methods are:

<u>Method</u>	<u>Output</u>
Tractor Sprayer – 7 nozzles	14 ha per day
Tractor Sprayer – 9 nozzles	18 ha per day

Tractor Sprayer – Mist blower
Knapsack Sprayer

30 ha per day
2 ha per day

GROUND NUT PRODUCTION

- Groundnuts are an important oilseed crop. Apart from human consumption it can also be used as fodder and it generates residual nitrogen.

Two main cultivars are grown in Zimbabwe;

- Long season varieties (150-190 days and short season varieties (100-140 days).
- The most recommended variety is Falcon.

Climatic Requirements

- It requires a frost-free period and the optimum temperature is 25- 35 °C.
- The crop needs 500-600mm during growing season.

Soil Type

- Requires a deep, well drained soil with pH 5.3- 6.5.

Spacing

- 50-75mm in row and 450mm interrow and a depth of 50-75mm.

Land Preparation

- Discing should be done followed by deep ploughing and harrowing

Planting

- Planting should be done with first effective rains (Mid Nov to Mid Dec).
- The seeding rate is 80-100kg /ha.

Fertilizer

- Apply 100-300kg of gypsum at pegging stage (50% flowering).
- Well-decomposed farmyard manure should be applied at the rate of 5-10tonnes /ha one month before sowing and incorporated into soil.

Irrigation

- Maintain optimum soil moisture at flowering and pod formation stages.
- In general, 8-18 irrigations at 15- 20 days after sowing and then 2nd application, 20-25 days after first irrigation. And subsequent irrigation should be given at 7-10 days intervals.

Weed Control

- The critical period of weed-crop competition is 28-45 days after sowing. Generally one hand weeding at 30 days and 2 weedings, 15 days afterwards and 35 days later will suffice. It might be necessary to use herbicides such as;

Alachlor - 1.5kg/ha applied as a pre emergence to control most monocots.

Fluchloralin -1.5 kg/ha applied as a preplant to control dicots

Dual -1.5kg/ha applied as a post emergence to control grassy weeds.

Pests And Diseases

PEST	DAMAGE	CONTROL
Leaf miner	larvae mine into leaves when they hatch from eggs and then emerge and web adjacent leaflets together to give a burnt look from afar	Dimethoate Monocrotophos
Aphids	Nymph and adults suck sap from tender growing shoots , flowers and pegs causing stunting and distortion on foliage	Dimethoate
Thrips	Nymph and adults sack sap from surface of leaflets causing white patches on upper & necrotic on lower surface	Dimethoate
White grub	Feed on rootlets and nodules or tap roots and plants wither and die	Carbamates

Sunflower

(Helianthus Annuus Var. Macrocarpus)

Introduction

- The plant can grow on a wide range of soil types and is therefore grown in many parts of the country.
- The bulk of the sunflower crop, about 90% is produced by communal area and small scale farmers.
- Sunflowers are a drought resistant crop that can produce high yields on as little as 410 mm of rainfall provided the soil is moist just before and during flowering period.
- Sunflowers are suited to region II and region IV and will earn more than maize in these areas.
- They are mainly planted from mid-November-mid-February.
- Yield levels average between 1.5 t/ha with the November plantings and 0.5 t/ha with the end of January to February plantings.

Land preparation

- Sunflowers are sensitive to low pH and nematodes.
- Light soils, especially sands should be checked for these factors before planting.
- Ploughing should begin in early November or as soon as the plough will easily enter the soil. (I.e. after the first rains).
- Ploughing should be done to a depth of at least 150 mm.
- A rough seedbed will cause uneven germination therefore clods should be broken before planting.
- Weeds should be removed before planting and use ripper tyne every two years.
- The most critical period for moisture is 20 days before flowering, throughout the flowering stage up to 20 days after flowering.

Plant spacing

- In regions which receive high rainfalls (regions I, II, III) a spacing of 90x 25 cm is recommended whilst in region IV and V a spacing of 90x 30 cm is also recommended.
- Planting lines can be made by opening a shallow furrow with ripper tyne. The seed should be planted 4-5 cm deep.
- 6 kg/ha of seed is sufficient if using hybrid or certified seed or up to 8kg for home retained seed.

Fertilization

- **The** general recommendation is to use at least 250kg of compound L fertilizer. This fertilizer should be applied at or before planting.
- A top dressing of 100kg Ammonium Nitrate can be applied 8-10 weeks after germination.

Weeding

- Mechanical control can be done.
- Under certain circumstances herbicides such as trif, lasso and dual can be used

Pest control

Semi looper

- They consume leaf tissue between the veins. A severe attack can cause defoliation.
- It can be controlled by use of chemicals such as Trichloform, Endosulfan or Carbaryl

African bollworm

- Caterpillar damages the crop by feeding on leaves, tender stems flowers and soft seed
- .It can be controlled as for semi loopers.

Cutworms

- They feed on young tender foliage near the soil surface and reduce the crop stand.
- They can be controlled using chemicals like trichloform bait, Endosulfan Bait or **Carbaryl**.

Tip wilter

- They feed by sucking the sap and causing plants to wilt and die.
- They can be controlled using chemicals such as Carbaryl and Endosulfan.

Seed Bug

- They feed on developing seed and cause it to shrivel.

- They can also feed on the stem below flower head.
- Control is the same as for tip wilters.

Diseases

Foliar diseases

- Can be controlled by rotation and field sanitation.
- Select resistant varieties

Sclerotinia Rot

- Can be controlled by using certified seed.
- Grow in a four year host free rotation and avoid excessive fertilisation.

Harvesting

- The seed is mature when the backs of the heads have turned yellow and the bracts are turning brown.
- At this point the moisture content will be 50% and the seed too wet to harvest.
- Once the heads and bracts have turned brown the moisture content will be 16-20% and combining can be started.

Bambara Groundnut

Common name: Bambara groundnut or Bambara nut

Scientific name: *Vigna subterranea*

Shona: Nyimo

Ndebele: Indhlabu

Brief background

Bambara groundnut is widely grown in the smallholder sector. It is native to the African continent. Research results show that the crop has considerable promise for commercialisation.

Soil type

- The crop grows well on well drained with soils pH of 5.0-6.5

Production areas

- The crop can be grown in all the natural regions of Zimbabwe.

Rainfall and climatic conditions

- Best growing temperatures are 20 C to 30 C and the rainfall range is 600-200mm.

Crop rotations

- Rotate with cereals such as maize, millet, sorghum and root crops such as sweet potato. Fallow lands are productive when grown to Bambara groundnut

Varieties

- .Currently Zimbabwe has no released varieties on the market and production is based on land races.

Planting

Spacing

- Natural regions I, II and III (or under irrigation) use 45cm between rows and 15cm between plants in the row.
- up to 20cm between plants in the row in dry areas

Seed rate:

- 27-135 kg/ha depending on seed size (lower rate for small seeded types and higher rates for larger seeded types). Plant one seed per station.

Planting time:

- Mid November to mid December with effective rains.

Seed dressing

- Use Thiram 80% WP at 70g/0kg of seed.

Earthing up

- For good pod development and pod filling, earthing up is recommended after flowering has started or at pegging. Pods that develop above ground result in green coloration and the seeds are smaller.
- Care should be taken when earthing not to go too close to the plant as this might damage pegs.

Fertilizer

- After a well-fertilized crop such as maize apply phosphorus fertilizer at rates of 40 to 60kg/ha and potassium fertilizer at rates of 25 -30kg.
- In poor soils, an application of 200-250kg of Compound D

Weed control

- Weeding should be done 15 days after emergence and then before clusters join.
- The herbicide Metachlor (Dual) applied pre-emergence at 1.7L/ha can be used to control most annual weeds. Alternatively, hand hoes are used.

Harvesting and shelling

- Harvesting is done when the crop turns yellow and the leaves have fallen.
- The shell will completely separate from the seed and the seed will be shiny and tough.

Storage

- Shell only when you need to use the seed in order to prevent weevil damage.
- Apply grain protectants such as asphostoxin tablets.

Disease and pest management

- The few known diseases of economic importance are leaf spots, pod rots and wilting diseases.
- Pests include aphids and ants in the field and storage weevils.

Marketing

- Most of the crop is marketed on the informal market with unspecified amounts going across borders, especially to South Africa, Botswana and Namibia.

Cowpea Production

Common name: Cowpea
Scientific name: *Vigna anguiculata*
Shona name: Nyemba
Ndebele name: Indumba

Introduction

- Mainly grown as a low input pulse. The leaves and grain are a source of protein.

Soil type

- Best yields are obtained from well drained soils with a pH of 6.0 to 7.0.

Production Regions

- Cowpea does best in natural regions III, IV and V.

Rainfall and climatic conditions

- 250 – 500mm rainfall is adequate for cowpea production.
- The crop is prone to frost but high temperatures cause flower and pod drop.

Varieties

- Varieties available are CBC1, IT 18, CBC2 and CBC3.
- There are two basic types of cowpea the upright and bunch types mainly used for grain production and the spreading types mainly used for grain, vegetable or fodder.
- Improved cultivars such as CBC1 and IT 18 are ideal for grain production but are of low leaf yield.

Spacing

Sole spacing:	plant type:	spacing	seed rate
	Bushy	45cm x 15cm	40-50kg/ha
	Spreading	75cm x 20cm	20-25kg/ha
Intercropping:	bushy	180cm x 15cm	10-15kg/ha
	Spreading	180cm x 30 cm	5-10kg/ha

For sole cropping use the following rates:

Bushy types: 30-50kg/ha (120,000 plants /ha)

Spreading types: 12-15kg/ha (60,000 plants/ha)

Planting depth: 5-7cm

Planting time

- Can be planted from end November to first week of January.
- In high rainfall areas it is best to plant late from mid December to avoid diseases.

Seed Dressing

- Use Thiram 80% WP at 70g/100kg of seed if not certified to control damping of seeding disease.

Fertilizer

- Cowpea responds well to manure or use-200kg/ha of compound fertilizers

Weed control

- Weed as early as possible until crop canopy is formed to smother late weeds.

Pest and disease control

Pest	Control	Pest	Control
Aphids	Rogor	Pod borer	Endosulphan

Suckling bugs	Endosulphan	Beetles	Endosulphan
Thrips	Cypermethrin	Storage weevils	Any grain protectant
Disease	Control	Disease	Control
Scab	Uneconomical to control	Ascochyta	Uneconomical to control
Bacterial blight	Benomyl	Bacterial leaf spot	Benomyl

Harvesting and threshing

- Leaves can be harvested from four weeks after planting to the onset of flowering.
- Harvest pods when they are relatively dry and thresh when completely dry.

Storage

- Dry to less than 11% moisture before storage.
- Use any grain protectant against cowpea weevil.
- Hessian bags store and maintain seed viability better than polypropylene bags.

Seed Selection

- Cowpea seed can be retained for up to 3 harvests as long as it is treated with Thiram 80% WP, stored in Hessian bags and kept off ground.

Rice

- Common name:** Rice
Scientific name: *Oryza sativa*
Shona: Mupunga
Ndebele: Umphunga

Brief about rice

There are two major groups of cultivated rice, namely *Oryza sativa indica* and *Oryza sativa japonica (sinica)*.

Climatic conditions affecting production

- Warm season varieties require temperatures of 25-35°C while the temperature for tillering and vegetative growth is 30° C.

Varieties

- The main variety grown in Zimbabwe is Blue Belle.
- Mhara2 and Mhara 4 have also been released. These mature in 100 – 105 days in the low veld and yield in the region of 6 – 8 t/ha.
- Mhara 3, which matures in 104 days and is Blast resistant and high yielding, is intended for production in seasonally waterlogged wetlands (*vleis*).

Seed availability

- Most of the seed of rice varieties is found at Chiredzi Research Station in the low veld.

Cultural practises

- Rice requires well drained soils and is established from seed.
- Wheat drills can be used for seedling with a seed rate of 90kg/ha however comparable yields have been obtained with varying seed rates of 40-120 kg/ha.
- Seed is grown in rows 250-300mm apart.

Weed control

- Hand weeding three times per crop season is the conventional method of weed control.
- The following herbicides are registered for use in Zimbabwe: Basagran, Stam F34, Propanil and Preforan.

Fertilization

- Apply 140kg/ha of nitrogen, 80kg/ha of phosphorus (P₂O₅) and no potash in the lowveld.

Table for nitrogen top dressing

Medium season varieties	Short season varieties
$\frac{1}{4}$ at sowing as basal	$\frac{1}{3}$ at sowing as basal
$\frac{1}{4}$ at five weeks	$\frac{1}{3}$ at four weeks
$\frac{1}{4}$ at eight weeks	$\frac{1}{3}$ at eight weeks
$\frac{1}{4}$ at eleven weeks	

Pests

- The major pest of rice is the *Quelea quelea* bird, termites, aphids, and leaf eaters. Rodents are also a problem in rice production and rodenticides such as Finale and Storm can be used.

- Spraying of birds at their roosting places can be done under the auspices of the Department of National Parks. On a small scale, bird scaring can be effective.

Diseases

Blast (*Pyricularia oryzae*)

- Causes bluish flesh on the leaves, which turn brown.
- High temperatures, humidity, dense stands and high levels of nitrogen favour the disease.
- Sow early before the onset of the rainy season to reduce the disease..

Brown Leaf Spot (*Cochliobolus myabeanus*).

- Brown spots on the lamina and sheaths and black spots on the husks of the grain.
- Favoured by cold weather.
- Seed dressing with Vitavax or Baytan reduces the incidence of this disease.

Harvesting

- Can be done manually or mechanically.
- Below are a number of guidelines that will ensure that grain quality is preserved during harvest operations, and that losses are kept to a minimum.
- Avoid delays in thrashing and avoid rewetting of harvested kernels
- Use proper thresher machine settings
- Clean grain thoroughly after threshing
- Harvest and thresh at night at 20-25% moisture content.
- Immediate threshing reduces the exposure of the crop to insects, birds, rodents, disease, and moulds.
- Avoid piling of the crop after harvest as this generates heat that serves as an ideal medium for growth of moulds, disease and pests.

Marketing

White seeded varieties are popular on the formal market while brown seeded varieties dominate the informal market.

Sorghum production

Back Ground

- It is used for food, feed, building material and fuel
- .It is mainly considered a subsistence crop because of its tolerance to drought and adaptation to dry tropical ecosystems.

Climatic requirements

- It is adapted to marginal rainfall areas when compared to other cereals
- Sorghum can be grown in any area that receives between 300 and 900 mm of rain that should be well distributed through out the growing season.

- Can be grown in all soil types even though higher yields are obtained on sandy loamy and heavy textured soils.
- The soil should be deep and well drained..
- The ideal soil pH is 5.0 and 6.5.

Fertility management

- Normally band applications of moderate rates of compound D are used at a rate of 150-300 kg/ha depending on the inherent soil fertility levels.
- Ammonium nitrate at a rate of 100-200 kg/ha is used as a top dressing fertilizer and is applied 6-8 weeks after emergence.
- In very light and inherently infertile soils it is recommended to split apply the top dressing fertilizer at least 2 weeks.
- Sorghum has also been observed to respond well to farmyard manure.

Variety Choice

- The national sorghum improvement program has developed a number of sorghum varieties that have proved to out yield farmers varieties in terms of grain yield.
- The available sorghum varieties are SV-1, SV-2, SV-3 and SV-4.
- Private companies have developed some varieties that can be accessed on the market.

Table 1: Description of Sorghum varieties

Variety	Characteristics
SV-4	It is a semi dwarf open pollinated variety that is more uniform in height with an average height of 1,30m. It is a medium maturing variety that produces whole white bold grain. Grain type is corneous to hard hence good milling qualities of up to 70% flour yield. The panicle is big and semi compact with good exertion (12-16 cm). Physiological maturity is within 113 to 127 days. SV-4 generally does not tiller. SV-4 has a high yield potential of between 3.4 and 9.0 t/ha.
SV-3	SV-3 is a creamy white-grained sorghum open pollinated variety that is semi dwarf in height. Plant height ranges from 1.14 to 1.59m depending on environment and it also show a high degree of uniformity. It produces a semi loose heads that mature in 112 to 124 days. The grain texture is corneous to hard and has a flour yield of up to 70%. SV-3 has a high crude protein quality (10.35%). It can tolerate <i>Striga</i> better than SV-1 and SV-2. It generally does not tiller. This variety has a high yield potential of between 3,8 and 8 t/ha.
SV-2	A semi dwarf variety with an average height of between 1,4 and 1.6m with a characteristic thin stem. It is an open pollinated variety with characteristic pearl white grain. This is so far the earliest maturing variety that matures in about 110 to 115 days and has also shown some tolerance to drought. SV-2 has good milling quality and it produces up to 70.4% flour yield. Tillering is minimal with an average of 1.5 tillers per plant. Yield ranges between 3 and 6 t/ha.
SV-1	SV-1 is a creamy white seeded open pollinated variety that was developed in Zimbabwe in 1985. It is a semi dwarf variety with a semi compact medium sized head that is well exerted. Average plant height is 1.25-1.8m. Physiological maturity is attained in about 115-125 days. SV-1 can tiller to produce 2-3 tillers per plant and is also photosensitive. Grain texture is very hard hence an excellent milling quality of 85% flour yield. Yield ranges between 3 and 6 tons/ha

<i>Macia</i>	An open-pollinated variety with creamy white seeds. 1.2 to 1.5 m tall, 115 to 120 days to maturity. Excellent milling quality to produce up to 80% flour.
<i>DC-75</i>	A hybrid red-seeded variety needs 120-125 days to maturity. Normally used for brewing. Yields from 3-6 tons/ha
<i>NS55</i>	<i>A hybrid with brown seeds which requires 110-120 days to maturity.</i> Yields from 4-6 tons /ha
<i>Pan 888</i>	<i>A hybrid forage sorghum variety which can be cut or grazed at 60-90 cm</i>

Seed rates/ planting populations

- Seed rate of 8-10 kg /ha is recommended to achieve a plant population of 130000-150000 plants/ha.
- The recommended spacing is 75 cm between rows and 15-20 cm between plants in a row.
- The common practice of planting is broadcasting seed on a well ploughed land and covering lightly using a light harrow, bush drag or cattle driven over the lands and covered to a depth of 2-3 cm.
- Mechanical planting can also be done but this will require high seed rates and will require more labour for thinning

Weed management

- Sorghum is very sensitive to weed competition especially during the early stages of growth and establishment.
- Normally 2-3 hoe-weeding regimes are done even though the use of pre-emergence herbicides like atrazine can be recommended in soils with greater than 25% clay content.

Thinning

- Thinning should be done to establish an in- row spacing of 15-20 cm and this should be done before tilling begins and is normally done 4 weeks after emergence.
- At this stage it is also recommended to fill in for the seeds that that did not germinate or seedlings that were affected by diseases.

Disease and pest management

The tables below show some of the common pest and diseases on sorghum in Zimbabwe.

Table 2: Common pests of sorghum in Zimbabwe

Pest	Symptoms/damage caused	Control
Shoot fly	Feeding larvae cause drying up of central leaf and dead heart symptoms in 1-4 weeks seedlings	Timely planting, use of high seed rates Chemical control using thionex, carbaryl etc).
Aphids	Found on the under side of leaves and funnel.	Chemically using

	Secret honeydew that leads to sooty molds growth.	malathion, dimethoate (rogor), diazinon
Spider mites	Suck sap from leaves to cause stunting. Mainly prevalent during hot dry spells	Spaying with acaricides like
Stalk borer	Penetrate stem through funnel at any stage of growth	Use chemicals like endosulfan, carbaryl, thionex, carbofuran
Head bugs	Adults suck sap from the developing grain	Control chemically using dimethoate
Armoured crickets	These feed on the sorghum head thereby reducing grain yield	Control biologically by scouting and hand picking but chemical control may be used.
Head bugs	They suck the sap in the spikelets during grain filling	Chemically using dimethoate
Birds	Remove sown seeds or seed from panicle. Less damage when crop mature at same time or on extensive sorghum fields	Scaring is the answer to the problem

Table 3: Common sorghum disease in Zimbabwe

Disease	Symptoms/ damage caused	Control
Stalk rots	Irregular molted pattern within internodes especially on peduncle.	Control (rotations, clean cultivation, destroy residues)
Downey mildew	Infected seedlings are chlorotic, stunted and may die pre maturely.	Treat seed metaloxyl, deep ploughing, use resistant varieties
Grain moulds	Molds develop on grain on the panicle especially when crop matures during periods of high rainfall and humidity	Control by adjusting sowing dates.
Ergot	Infection is from panicle emergence through fertilization May cause complete crop loss	Use of resistant varieties, proper rotations, destroy residues
Smut	Ear head become swollen and turn gray and	Spray with fungicides, use of resistant varieties, removing smutted heads

Harvesting/drying /storage

- Harvesting is normally done when plants reach physiological maturity. Leaves will be turn yellowish and beginning to dry up naturally..

Marketing

- Grain sorghum is marketed through the grain marketing board that presets the prices. Private companies like delta can buy brewing sorghum from farmers mostly those under their growers' contracts.

Millet

Background

- Adapted to harsh environments. Pearl millet hybrids are highly responsive to intensive crop production inputs
- Mainly grown in Matebeleland, Manicaland, Mashonaland East, Midlands and Masvingo province by smallholder farmers..

Climatic Requirements

- Adapted to warm dry climates of Natural region 3,4,5 that are marginal for Maize production.
- Growth temperature of 28–32°C is optimum for normal crop growth..
- It does not tolerate flooding..

Fertility Management

Fertilizer rate of 200kg/ha Compound D plus 100kg/ha Ammonium Nitrate can be used..

Varieties

PMV-1

- Is an average yielder Dwarf variety that matures early in 90-95 days. It is a high tillering variety with 5-10 tillers per plant.

TABLE: Agronomic characteristics of PMV-1

Yield Potential	2-3 t/ha
Days to Maturity	90-95 days
Grain colour	Grey seeded
Plant height	0.9 – 1.3 (dwarf)

PMV-2

- Is an average yielder which escapes drought and matures in 95-100 days. It produces 3-5 effective tillers and the head shape is candle like.

PMV-3

- PMV-3 is currently the highest yielding pearl millet variety. It is drought resistant, matures early in 85-90 days. And has an intermediate height with 3 –5 effective tillers. The head shape is cylindrical to lanceolate.

Seed Rates/ Plant Population

- Seed rate of 6– 10kg /ha is recommended the crop will be thinned to 50 - 75cm inter-row and 20– 30cm in-row to give a population of 53 333 to 100 000 plants per hectare.

Planting Time/Depth/Method

- Depth varies from 25 - 75 mm the optimum being 35-45 mm. Sowing depth varies in different soils and climate condition:

Optimum sowing depth	–	3.50–4.50 cm
Heavier soils	–	1.25–2.50 cm
Red soils	–	2.50–5.00 cm
Desert sandy soils	–	5.00–7.00 cm
- The crop is planted in early summer to late summer (i.e. from November to end January) The crop can be planted by broad casting, hand drilling and machine drilling in rows and also can be transplanted when it has reached close to knee-height or at tillering.

Weed Management

Competition with weeds reduces grain yield by 25–50%. For effective weed control, following two alternative measures are recommended:

- Two manual weeding along with hoeing 15 and 30 days after sowing are most effective.
- Application of pre-emergence herbicide atrazine at @ 0.5 Kg a.i. ha⁻¹, followed by one hoeing after 3 weeks of sowing is effective and more economic

Pests Control

- The red –billed weaverbird and Quelea can be controlled by scaring or use of bristled varieties.
- The stem borer and shoot fly are also damaging, can be controlled by crop rotation and use of insecticides like carbaryl, malathion and endosulfon.

Disease Control.

Major diseases

Causal organism

- | | |
|-----------------|-------------------------------------|
| 1. Downy mildew | <i>Sclespora graminicola</i> |
| 2. Ergot | <i>Claviceps fusiformis</i> |
| 3. Smut | <i>Tolyposporium pennicillariae</i> |

Downy mildew

Downy growth covering mostly under-surface of the leaf and ‘green ear’ as small green leaves replaces grains in the ear head.

- Use resistant cultivars.
- Seed treatment with Apron S.D. 35 @ 6 gms kg⁻¹ seed.
- Foliar spray-Ridomil 25 WP (100 ppm) after 21 days of sowing if infection exceeds 2–5%.
- Infected plants should never be allowed to remain in field. Such plants should be uprooted and burnt.
- Avoid monoculture of particular cultivar.

. Ergot

Honey-like secretion dries on earhead and later becomes hard in place of normal grain.

- There is no effective control measure through fungicides; therefore genetic resistance is the best option.
- Precautionary measures.
 1. Dip seeds in 20% brine water solution, stir and remove floating seeds and sclerotia. Seeds lying in bottom be dried and sown.
 2. Adjust sowing dates so that ear emergence does not coincide with more rainy days.
 3. Plough the field soon after harvest so that ergot is buried deep.

Smut

- Grain or grains becomes in infected earheads becomes swollen and turn dark brown.
- Host resistance in best way to control.
- Spray of with fungicide Captafol (2 ppm) followed by Zineb (2 ppm), on panicle at boot leaf stage reduces infection, but is not economic measure.
- Remove smutted ear.

Rust

- Host resistance in the best remedy.
- Fungicidal spray Zineb 0.15% attains varying degree of success on rust incidence.

Harvesting/Drying/Storage

- Pearl millet is ready for harvest 3- 4 weeks after flowering.
- The crop is harvested by hand, by clipping the heads from the standing stalks this allows periodical pickings to reduce field damage from birds leaving the green heads to mature out
- The crop is either stored unthreshed or threshed.
- The grain is treated with insecticides such as Malathion, Lindane dust or neem tree leaves are scattered throughout the grain to prevent insect attack and other cereal insecticides can be used.

Finger Millet

Importance

- Mostly grown in Mashonaland, Midlands, Masvingo and Manicaland provinces.
- Its uses include preparation of beer, food for pregnant woman, young children and for the sick, possibly due to the high calcium and iron content in the grain.

Climatic Requirements

- It grows on a wide range of soils.
- It tolerates dry spell in the early stages of growth and then grows rapidly

Land Preparation

- Bed preparation should be thorough because of the small seed and because it cannot stand weed competition

Fertility Management

Fertilizer rate of 200—300 kg/ha Compound D plus 100 –150 kg/ha Ammonium

Varieties

FMV-1

FMV-1 is higher yielding than local

- Nitrate is required
- Varieties and is the earliest to mature in 120-130 days. The variety is used for food and brewing.

FMV-2

- The variety is higher yielding and
- Matures late in 150 –160 days. The variety is used for food and brewing.

Seed Rates/ Plant Population

- Seed rate is 3– 5 kg /ha. The crop can be planted at 50 cm inter-row and 15 –20 cm
- In-row to give plant population of between 100 000 to 133 333 plants per hectare.

Planting Time/Depth And Method

- Being a small seeded it is usually surface sown. Rolling after sowing would improve germination.
- It is sown early in the season with the first rains or in October– November or late towards end of December. It is either broadcasted or drilled in rows.

Weed Management

- Ability to compete with weeds is poor.

- It is mostly hand weeded to remove *E.indica* and *E. Africana*. These are hard to distinguish from finger millet in the young stage.

Diseases and Pest Management

Head Blast caused by *Piricularia oryzae* which also attacks rice, can cause damage.

Harvesting, Drying and Storage

- Finger millet is ready for harvest 3- 4 weeks after flowering, is harvested by hand, by clipping the heads.
- Crushing with a heavy stoneroller or flailing often threshes this crop.

Winter Wheat production

Common name: wheat
 Scientific name: *Triticum aestivum*
 Shona name: Gorosi
 Ndebele name: Ingqoloyi

Introduction

- Wheat is the second most important cereal crop in Zimbabwe in terms of quantities consumed.

Climatic factors affecting Wheat

- Grows well under temperate conditions.
- High temperatures after flowering reduce period of grain filling and hence yield.
- Frost during ear emergency and flowering may cause floral sterility thereby reducing grain set.
- Severe frost after heading can destroy the stem just below the ear thus stopping further development of grain.
- Severe frost after grain setting may cause moisture within the grain to freeze thus distorting and damaging the grain and affecting test density.
- The most sensitive periods for water stress in wheat are during heading, flowering, and early grain filling.
- Drought during these periods reduces yield.
- Rainfall during and after hard dough stage can cause germination of the grain in the ear of some varieties, which reduces the taste density and quality.
- Early rains can cause lodging, down grading of wheat and interfere with harvesting.

Wheat Varieties and characteristics

<i>Variety</i>	<i>Yield level</i>	<i>Lodging</i>	<i>Diseases</i>
<i>Seed Co</i>			
SC Nduna	Very high white coloured grain and has good grading and baking qualities	Resistant but medium to tall in height	Immune to stem rust, moderate resistant to leaf rust and powdery mildew. Have high field resilience
Smart	High yielding, red coloured grain and has good grading and baking qualities.	High lodging resistance because its of medium height	Resistant to powdery mildew and recurring stem rust, Have high field resilience, not resistant to sprouting
Shangwa	High yielding, white grained variety with exceptionally high protein content	Resistant to lodging due to its short stature	Immune to stem rust, leaf rust, and powdery mildew.
Stallion	Very high yielding (up to 10t/ha) red	Medium to tall in height	High disease tolerance levels for stem rust, leaf

	grained early maturing variety		rust and powdery mildew
<i>Pannar</i>			
Pan 3490	High yielding (up to 6-8t/ha) and matures in about 158days	Have good straw strength	Excellent leaf, stem and stripe rust resistance with moderate resistance to powdery mildew
Pan 3492	High yield potential and matures very early	Tall and has good standability	
<i>Government bred</i>			
Kana	Red grained cultivar	Dwarf hence reasonable lodging qualities	
Insiza	White grained early maturing variety of good quality.	Semi dwarf	Resistant to current leaf rust strains

Soil Requirements

Requires deep heavier textured soils, well drained and with good organic matter status.

Convectional Tillage

- Usually involves primary tillage operation (ploughing or ripping) followed by secondary tillage to create a seedbed (disc or tine harrow with or without rolling).
- Rolling is necessary for rough soils.
- Ploughing can be done every 2 to 3 years (with a ripper or chisel plough used in other years).

Planting

- Broadcast seed over the residue using an oscillating spout (VICON) or double spinning disc fertiliser spreader or convectional seed drill planter with the counters removed.
- Fertiliser should also be broadcasted on the surface after the seed.
- Seed rates should be 10 - 20% greater than under drilled conditions because seed losses are higher. It is important to check distribution of seed and fertilizer when fertiliser broadcaster is used.

Checklist to get an even distribution when broadcasting seed and fertiliser;

- There must be 100% overlap of swath
- The height the product leaves the machine is critical.
- The nylon tip on oscillating spout machines must be in good conditions
- On spinning disc machines the length of band arms of the fingers must be set according to the instructions for the swath width and the size range and density of the material being used.
- Fertiliser with wide varying prill sizes and blends are not good for very wide swath width.
- If all the above have been tried and variation is still unacceptable and then reduce swath width.

Direct seeding

- This can be done into maize or soya bean residue in two ways that are with the use of no till drill, broadcast and light disc system.
- Irrigation may be applied at 2-3 day intervals.

Planting dates

Area	Planting dates	Reason
Highveld	Up to 25 May	To avoid the coinciding of flowering with frost
Middleveld	7 to 15 May	
Lowveld	1 to 10 May	To avoid sharp rising temperature during grain filling stage

Seed Rates

- Broadcasting – 120 -130 kg/ha
- Drilling- 100 to 120 kg/ha.
- At Least 10% of required seed is purchased each year to maintain quality.
- The ideal planting depth is 30 mm.
- Row spacing is 15-25 cm.

Nutrients requirements

Fertilizer type	Application rate (kg/ha)	N%
basal	300-500	7
Ammonium nitrate (AN)	300-400	34.5
Urea	225- 300	46
Lime ammonium nitrate (LAN)	350-500	28

Options of applying urea

First option

- Mix the required basal and half of the total urea
- The mixture is applied and incorporated into soil just before planting using disc or roam harrow.
- If seed drilling method is used then the mixture can be applied during seed drilling
- The other half urea can be applied at flowering (6- 8 weeks)
- At flowering apply the urea followed by a light irrigation of water about 3-4 hours around 15-20 mm
- Urea should be applied to an area that can be covered by an irrigation cycle.

Second option

- On heavy soil, apply the urea in one application at 14-21 days after emergency
- On sand split applications can be done at 14 days and at 35 days after emergency
- Immediately follow with a light irrigation of water about 3-4 hours around 15-20mm
- Urea should be applied to an area that can be covered by an irrigation cycle

Weed control

Start with a clean seedbed by controlling late weeds in summer. Scout for weed infestation early 2- 3 weeks after emergency and again 10 days later. After scouting decide which of the following policies to adopt:

No weeds	No need to spray
Isolated weeds	Hand pull
Weeds in patches	Spot spraying
Weeds present throughout the land	Overall spray

Chemical weed control

The choice of the herbicide is depended on the weeds not on the cost

Name of herbicide	Stage of application	Rate of application	Types of weeds
Banvel	3 leaf stage after emergency	250ml/ha	Control of broad leaf weeds
Ally	Any time after emergency	20g/ha	Control of broadleaf weeds
MCPA	3 leaf stage after emergency to 30 days after germination	2.5l/ha	Control of volunteer soyabeans
Pumer super	After emergency	300-500ml/ha	Control of annual and perennial grasses
Ally + Banvel mix		5g +100ml+ 0.1% Sanawett	As above
Banvel + MCPA mix		250ml +750ml	As above
Roundup (Glyphosate- <i>a I</i>)	At 6 leaf stage of weed. Applied as a pre plant for zero or minimum tillage	1l/ha	Control all weeds and even tree shrubs (The tree shrubs should be cut and roundup is applied on the cut stumps)

Irrigation

The most critical stages of moisture require are during root development, heading, early flowering, and early grain filling (milk dough stages). Water

The following recommendations can be used

- Pre irrigation before sowing and bringing soil slightly below field capacity
- Immediately after sowing 22 mm of water should be applied and this is repeated five days later
- Water is applied again 3-4 weeks after sowing or when the crown roots have developed.
- Apply 44mm after top dressing and herbicide application.

Recommended water requirement for a season ranges from 350-600mm.

Irrigation Scheduling

The maximum irrigation cycle length (days), which may be employed on wheat under deficit irrigation, is as follows:

Soil texture	Highveld	Middleveld	Lowveld
Sand	11	9	5
Sand clay / loamy	15	13	7
Clay	18	16	9

Major diseases

Disease	Occurrence	Symptoms	Control
Wheat leaf rust	Highveld, late July – September. Lowveld, early June-July	Masses of light brown pores on leaves. Black spores later.	-Plant resistant/ tolerant varieties -Following recommended planting dates -Destruction of volunteer wheat plants - Spray with Shavit
Powdery Mildew	Excess nitrogen and water favours disease development	Colonies of white to grey cottony or fluffy growth with thousands of dry spores on upper surface of leaf	-Use resistant varieties -Avoid excessive use of water and nitrogen -Destroy volunteer plants -Deep ploughing and burying infected debris -Use of recommended plant populations -Rotations -Use of fungicides
Maize streak virus	Transmitted by leaf hopper	Chlorotic streaks on leaf blades Stunted plants and may not bear heads depending on stage of attack	-Control vector using insecticides -Breed for resistance
Loose smut		Kennel of infected plants are transformed into a mass of dark powdery spores covered with a thin membrane	-Rogue and burn all infected heads -Plant certified seed -Treat seed with systemic fungicides (Baytan, Vitavax) -Use of resistant varieties -Rotation

Pest	Management
Quelea birds- have red beaks and move in flocks of up to a million birds, they feed on soft dough wheat grains and start from the edge of the field. A bird a feed up to 4g/day and can destroy up to 10g. They roost near water sources and this may be about 50km away from field	-Identification of roosts -Informing AREX and Parks and Wildlife Management Authority -Spraying roosts using Fenthion 640 UL (Queletox, Shiritox640 UL) -Bird scaring -Mist nests: harvesting for relish -Blasting
Aphids – These feed on leaves of developing ears. They are small and green in colour. They pierce, suck, and found on underside of leaves.	-Regular scouting -Chemical control using; Systematic insecticides- Dimethoate(rogor) , Carbosulfan (Marshal), Dimeton-S-Methyl (Metasystox),

May cause leaf curling	Monocrotophos, Pirimicarb (Pirimor 50 DG), Thiometon (Ekaton 25 EC)
Armyworm- the larva stage feeds on the leaves of the crop. Serious damage may be caused in young seedlings if outbreaks are not controlled	- Use Carbaryl 85% WP 625g/ha as soon as pest is noticed
Leaf and ear caterpillar- these feed by eating or stripping the leaves. Serious damage may result if outbreaks are not controlled.	- Can be controlled by Carbaryl 85% WP at a rate of 625g/ha or Malathion 50%EC at 600-1200ml/ha
Leafhoppers- these can transmit streak virus	Dimethoate 40% at a rate of 70ml/ha

Harvesting

- Should be done when wheat is fully ripe at 12.14% moisture level.
- For large scale use a combine harvester and for small scale it can be done by hand.

Assessing field loss

A total of 50 to 60 grains per 0.1m² indicate loss of 50 kg/ha. Field losses of 1 to 1.5 bags are a great loss. Combine blades should be fixed so as to avoid great loss.

Oats

Land Preparation

- Oats can be grown on a wide range of soils and will tolerate more acidic soils than either wheat or barley.

Cereal	pH range
Oats	4.5-5.5
Wheat	5.1-7.0
Barley	5.5-7.0

Good land preparation is essential for establishment of a good crop. Land should be ploughed to a depth of 150- 225mm and harrowed and/or disc to produce a fine seedbed.

Planting Dates

Variety	Days to mature	Planting date
Florida selected	160	End of April
Rapida	120-125	May onwards

Seed Rates

- 50-60 kg/ha if drilled or 70 kg/ha if seed is broadcasted.

Varieties

1. Florida selected- a late maturing variety, but high yielding
2. Rapida- an early maturing variety, medium to high yielding
3. Oatline Larry- a mid season maturing low yielding variety. It performs well under nitrogen regimes and produces much greater seed yield than Florida selected.

Fertilising

General Recommendations

Soil status	N (kg/ha)	P ₂ O ₅ (kg/ha)	K ₂ O (kg/ha)
Good	30	20-30	20-30
Medium	30-60	30-60	30-50
Poor	60-90	60-90	50-70

Apply nitrogen with caution especially Florida Selected grown for seed since it the variety is prone to lodging. If it is grown for fodder apply Ammonium Nitrate (25-30 N) top dressing of up to 75kg/ha after each cut.

Irrigation

- Similar to that of wheat and barley

Weed Control

- Apply Fenron at the rate of 1.7kg/ha at any stage and a lower rate of 1.0kg/ha 3 weeks after germination.

Diseases

Crown Rust (*Puccinia Coronata*)

- Small oval strange yellow particles scattered on both leaves.
- Controlled by using resistant variety

Barley Yellow Dwarf Diseases

- Causes reddening of leaves, stunting, an upright posture of thickened stiff leaves, reduced root growth and a reduction in yield.
- Heads of affected plants tend to remain erect and become black and discoloured during ripening due to colonisation by saprophytic fungi

Loose smut (*Ustilago Avenae*) –

- A seed borne disease, which reduces ears to black powder.
- Seed dressing best controls this disease.

Stem rust (*Puccinia Graminis var avenae*)

- Causes reddish brown elongated pustules on stems and leaves.
- No other known control methods other than planting resistant varieties.

Maize Seed Production

Site Selection

- Good fertility and near to a water source
- Easy accessibility to inspection, harvesting, processing and storage
- Protected from livestock
- Avoid fields that had maize the previous season

Isolation

- **Spatial isolation**
 - Minimum distance 300m though variable.
 - Vegetation barriers around the field are preferable
- **Time isolation**
 - Plant 6 weeks before or after the nearest maize crop
 - Check with neighbours' plants
 - Look out for volunteer plants

Soil and fertility management

- Requires a pH of 5.5-6 and Follow site specific recommendations

Yield expectation N fertilizer application

1 t/ha	30 kg N/ha
2 t/ha	60kgN/ha
3 t/ha	90kgN/ha
4 t/ha +	120kgN/ha

Land preparation and planting

- Fine and firm seed bed for good and uniform germination to ensure good seed soil contact.

Planting distances

Follow site specific recommendations and remember Low moisture and low fertility reduce plant density

High rainfall area – 4-5 plants/m² 0.9 x 0.3

Low rainfall area – 2-3 plants /m² 1.0-1.2 x 0.3

Very dry areas- 1-2 plants/m² 1.2-1.5 x 0.3

Weeding

Manual weeding

- Start as early as possible and weed a minimum of 2 times
- Small weeds are easier to control

Chemical weeding

- More effective but costly (must have knowledge of the weed spectrum)
 - Pre-emergence – Atrazine and Dual post-emergence
 - Basagran
 - Gramoxone
 - Bladex

Scouting and pest and disease management

- Scout and identify pest and disease before action

- Ensure proper and safe use of chemicals
- Rogue and burn diseased plants
- Remove alternative pest and disease host plants on and off season
- Keep the field weed free
- Use disease and pest free equipment (e.g. witch weed seed)
- Avoid unnecessary movement of people across the field
- Practice crop rotation

Common diseases:

- GLS – Grey Leaf Spot
- MSV – Maize Streak Virus
- Maize Rust
- Maize Blight – Turcicum
- Ear rots – Diplodia and Fusarium
- Phasoepheria Leaf Spot

Varietal Characterization

Why is this important?

- To benefit from the genetic advantages of the improved variety
- To enable rouging during seed production
- To identify the variety

Rouging

Avoid genetic contamination

- Ensure varietal integrity and purity
- Reduce incidence of seed-transmitted diseases

Avoid mechanical contamination

- Ensure physical purity of the seed
- Eliminate weeds
- Systematic evaluation of a seed production field
- Removal of all undesirable plants
- “Rogue” – any *atypical* plant that do not conform to the varietal description

Rouging” Before and During Planting

- Good site selection (no volunteers, weeds)
- Use good seed (Foundation seed)
- Verify that isolation is adequate
- Use herbicides; eliminate weeds

Rouging During Vegetative Cycle

- carefully rogue undesirable plants
 - Post emergence: can often be seed off-types (taller; thicker stems, different colour, out of place)
 - Flowering: earliest and latest plants to flower, tassel colour, silk colour, weak or diseased plants
- Clean all equipment before entering field (e.g. cultivator)
- Clean-up, rogue perimeter fields (isolation area) to eliminate maize (volunteers)

plants and problem weeds

Recommended seed moisture

- Harvest = 30-35%, Shelling = 14-16%, Storage = 12%

Sun drying

Done before shelling on either a clean and dry surface a patio with a concrete floor or on black plastic sheeting.

Mechanical drying

- Permits earlier harvest and Ensures higher seed quality.
- Is expensive in terms of equipment and power and initial investment and Can damage the seed if poorly managed
- Drying time is on average 4.5 hrs per 1% moisture
“Double pass” system
Initial maximum temperature: 28°C
Absolute maximum temperature: 43°C

Rouging During Harvest and Processing

- Use/display sample boards with example cobs to facilitate visual rouging of cobs.
- Remove partially filled ears, malformed cobs, diseased and germinating kernels, extremely dent kernels or flint.
- Clean all harvest and processing equipment.
- Tag/identify all harvested cobs, bags, seed containers and Store each seed lot separately from others

Shelling the Seed Crop

Manual shelling

- Rotten or deformed seeds are removed.
- Best seed quality is achieved and little mechanical damage occurs.
- Labour intensive and slow but allows shelling at higher moisture; then sun-dry grain instead of cobs.

Mechanical shelling

Seed moisture content is critical

Too wet: mushes, bruising whilst too dry: cracks, breaks

Just right: 14-16% moisture

Use slow speed (<300 RPM)

Hand-operated shelling machines can be very practical

Conditioning the Seed

- Enhances seed quality but does not compensate for poor production

Cleaning

- Involves the use of screens or sieves.
- Eliminates foreign matter, broken and shriveled seed.
- Winnowing can remove light, poor quality seed whilst.
- Gravity table uses air and vibration

Denser seed = healthier seed

Classification, sizing

- Use screens (large, small, flat, round)

Treating the seed

- Timing of treatment is important.
- Carefully use correct quantities, rate and ensure uniform coating of seed. Also ensure seed is at appropriate moisture content.

Packing/Bagging the Seed

- Requires accurately labeled packages which will make it convenient for handling and transport.
- Choose appropriate packaging for likely storage conditions. Paper is better than plastic in hot, humid conditions.

Protect seed against contamination and damage.

Seed Storage

Objective:

Keep seed in viable (germinable) condition until the next planting season

Dry, cool conditions are best. (Good sanitation practices are essential)

Seed Quality

- Viability = capacity of the seed to live, grow and develop.
- Germination = capacity of the seed to develop normal seedlings in optimum conditions.
- Vigor = properties of the seed which determine potential for uniform and rapid emergence and the development of normal seedlings in a wide range of field conditions.

Maize

Common name:	Maize
Scientific name:	<i>Zea mays</i> L.
Shona:	Chibage/Magwere
Ndebele:	Umumbu

Rainfall

- Favours long seasons (110-140 days) in which there is adequate moisture.
- Severe moisture deficit at tasseling and silking causes crop failure due to poor pollination.
- If rainfall is inadequate during tasselling/silking, it is advisable to irrigate the crop.
- Water logging also has negative effects on maize.

Temperature

- Mostly night temperatures tend to affect maize yields.
- Temperature also affects time taken to maturity. Lowveld area crops tend to mature much faster due to high photosynthesis.
- Temperatures above 38°C destroy pollen viability.

Soil types

- Sandy clay loams and heavier soils are most suitable.
- Soils should be well drained and the optimum pH range is 5.5-6.5
- On heavy soils pH should not be allowed to drop below 5.0.

Land Preparation

- Winter ploughing, immediately after harvest kills weeds, conserves moisture, controls pests and promotes early decomposition of weeds and residues.
- Summer ploughing and harrowing will create a fine tilth for planting.

Cultivar selection

There are two major groups of cultivars:

- Hybrids whose seeds cannot be recycled and
- Open-pollinated varieties, whose seed can be recycled for at least 3 seasons before buying fresh seed,

Some of the advantages of OPVs

- Cheaper seed
- Seed can be recycled for (2-3 season)
- Recycling hybrid seed result in loss of hybrid vigour, hence the need to buy seed every season.

Long season variety: Matures in 140+ days, e.g. SR52, SC701

Intermediate season variety: 130-140 days, e.g. SC627, ZS255

Short season variety: 120 -130 days, e.g. SC407, ZS257, SC403, SC401

- Long season and medium season varieties are recommended for high rainfall areas while short season varieties are for drier regions.

Seed rates

- On average 25kg/ha of seed maize is recommended.

Planting time:

- Dry planting can be done 2-3 weeks prior to the first effective rain or alternatively plant with first effective rains.
- Long season varieties can be planted with irrigation (where it is available) in mid October before the rain.
- Late planting of maize after mid-December reduces yields.
- Rotation can be done with legumes.

Plant population and spacing

- 45 000 plants/ha (90 cm x 25 cm) for high rainfall areas of NRI and NRII and
- 37 000 plants/ha (90 cm x 30 cm) for low rainfall areas of NRIII and IV
- 22000 plant/ha (1.5m x 30 cm) on tied ridges for dry areas of NRV.
- Varieties with short stature can be planted at higher plant populations.
- The general Planting depth is 50 mm, but variations can occur depending on soil type and planting method.

Fertilizer application rates and time:

Table showing general Fertilizer Recommendation according to soil fertility status

	Soil Fertility Status		
	Good	Medium	Poor
Fertilizer Nutrients	Kg/ha of fertilizer nutrient required		
N	Up to 100	100-160	160-200
P2O5	30-50	50-70	70-90

K ₂ O	20-30	30-50	50-70
Fertilizer in bags	3-4 compound D	4-7 compound D	7-10 compound D

Table 1: General recommended fertilizer rates according to Natural Region

Fertilizer	Natural II	Natural III	Natural IV
Compound/maize fertilizer (kg/ha)	300 to 350 (6-7 bags)	200 to 300 (4-6 bags)	150-200 (3-4 bags)
Ammonium nitrate (AN) top dressing (kg/ha)	250 to 300 (5-6 bags)	150 to 200 (3-4 bags)	100-150 (2-3 bags)

- Generally, the whole of P & K requirements and at least 1/3 N should be applied at planting by either broadcasting or banding in planting rows.
- The top dressing fertilizer (AN) is recommended at 4-6 weeks after planting or at maize knee height if applied once.
- If topdressing is split because of high rainfall, the first 1/3 can be applied at 4-6 weeks and the last 1/3 at 8 weeks after maize planting.

Liming

- It is recommended that fields be limed once in three years.
- General recommendation is 600-kg/ha limes.
- If the soil is strongly acidic comparatively large applications of lime are required, 1/2 to 2/3 of the recommended lime should be applied in the first season and the remainder in the following season.
- It is important that the lime should be incorporated through out the plough Zone (30 cm). It is recommended also that it be applied after winter ploughing to give it time to react with soils before planting.

NB manure & ash have liming effects on soils

Other soil nutrient replenishing methods to supplement inorganic fertilizers:

- Use of cattle manure, cured in pits or heaped.
- Rotation mainly with grain legumes such as groundnut, Bambara groundnut (Nyimo /indhlabu) and soyabean.
- Maize intercropping with legumes such as cowpea (Nyemba / indumba)
- Green manuring using legumes such as velvet bean and sun hemp
- Use of agro forestry species such as e.g. *Sesbania sesban* for improving fallows before planting maize.
- Use of termitaria (termite mound) soils
- Use of compost and ashes in fields to be planted to maize

Weed management

A maize crop should be maintained weed-free for at least 2 to 6 weeks after establishment.

There are basically three types of weed control practices used in Zimbabwe

- Hand weeding, using a hoe
- Mechanical (using ploughs and cultivators) in combination with hand hoeing
- Use of herbicides. Atrazine is the most common herbicide recommended for use in maize. It can be combined with mechanical weeding by applying a rate reduced by 50% in the crop

rows only and using the cultivator or plough in between the maize rows. Atrazine controls most broad leaf weeds, but depending on the weed species, other herbicides may be recommended.

Pests and diseases

Table 2: Major maize diseases and insect pests and their cultural or chemical control

Diseases	Cultural and/or chemical control	
Leaf blight	Breeding for resistance and use of rotations	
Leaf streak virus	40% Dimethoate at 50ml in 455 litres of water	
Boil smut	Standard seed dressing eradicates the seed borne infection	
Bacterial stalk rot	Do not irrigate in hot, sunny conditions	
Maize rust	Breeding for resistance	
Grey leaf spot	Breeding for resistance	
Pests	Chemical control: Active ingredient	Trade name
Aphids	<ul style="list-style-type: none"> • Demeton-S-Metyhyl • Dimethoate • Thiometon 	<ul style="list-style-type: none"> • Metasystox 25 EC • Dimethoate 40 EC, • Rogor CE • Ekatin 25 EC
Armyworm	<ul style="list-style-type: none"> • Carbaryl • Malathion 	<ul style="list-style-type: none"> • Carbaryl 85 WP • Malathion Dust, • Malathion 50 EC
Leaf hopper	<ul style="list-style-type: none"> • Benfuracarb • Carbofuran • Imidacloprid • Dimethoate 	<ul style="list-style-type: none"> • Oncol 20 EC • Curater 10 G, • Carbofuran 10 G • Gaucho 70 WP • Rogor CE, Dimethoate 40 EC
Stalk-borer	<ul style="list-style-type: none"> • Carbaryl • Trichlofin • Endosulfan 	<ul style="list-style-type: none"> • Carbaryl 5 Dust, • Carbaryl 85 WP • Dipterex 2.5 Gran • Thiodan 1%
Termites	<ul style="list-style-type: none"> • Fipronil • Imidacloprid 	<ul style="list-style-type: none"> • Regent 250 SE, Regent 3 G • Confidor 200 SL

Weevils	<ul style="list-style-type: none"> • Pirimiphos methyl + • Permethrin • Malathion • Pirimiphos methyl 	<ul style="list-style-type: none"> • Actellic Super • Ingwe/Nhoro • Shumba 2 Dust
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Harvesting, drying and storage

- Maize can either be dried artificially or naturally.
- In natural drying, the cob is left on the plant and on small plots the sheath could be opened to speed up drying.
- Acceptable moisture for effective storage is 12.5%.

Marketing

- Marketing of maize grain is currently controlled by Legislation with the Grain Marketing Board being the sole trader.
- Innovative utilization at farm level i.e. for stock feed

Soyabean Production

Soils and climate

- The soyabean is suited to soils with high clay content. The optimum pH is 5.5
- .Soyabean requires reliable rainfall particularly from flowering to pod maturity.
- It is a good crop to grow in rotation with maize, cotton and wheat.

Fertilisation

- Soyabeans grow well on residual fertiliser.\
- General recommendation is 200 - 300 kg/ha of either a Compound fertiliser (D or L), Gypsum or Single Super Phosphate before planting.
- Soyabeans respond well to manure application.
- Soyabeans do not need much nitrogen either in the basal fertilizer or as top dressing they are able to obtain their nitrogen requirements from the soil air.
- It is therefore essential to apply *Bradyrhizobium* inoculant to the seed at planting.
- Do not leave the inoculant in a hot place, but store it in a cool, dark place.
- When ready to plant, the inoculum is mixed with a little water and sugar, and applied to the seed immediately prior to planting.
- One packet of inoculant is required for each 100 kg of seed. However, a higher rate is preferable on sandy soils or in first year soyabeans fields.

Cultivars

There are two basic types of soyabean cultivars: Determinate and indeterminate

- Determinate cultivars grow vegetatively for about six weeks and then begin flowering, having put on 10 to 12 leaves. Once flowering begins, no further new leaves are produced on the main stem.
- Indeterminate cultivars, on the other hand, grow vegetatively for about six weeks, then begin flowering when the main stem has about 10 leaves, but at the same time

as flowering, the stem continues to grow for another three weeks or so, producing another five to seven leaves.

- Determinate cultivars are better suited to warm fast growing environments where irrigation is available, like the lowveld, whilst on the middleveld and highveld, both types are suitable. Under drought conditions, indeterminate varieties may have some advantage over determinates.
- Some of the cultivars available include Soprano and Solitaire, which are indeterminate, and Storm and Soma, which are determinate.

Planting and crop management

- The seed rate is about 100 kg per ha.
- The desirable plant population is around 350 000 plants per ha. The minimum plant population is 200 000 plants per ha, while the maximum is 500 000 plants/ha.
- The row spacing may be from 25 - 90 cm.
- Do not plant seed deeper than 5 cm.
- Cover the seed such that the soil forms a slight mound over the row, as this makes it easier for the seedling to emerge.
- Seed should be planted 25-50 mm deep, depending on soil texture. If soil crusting occurs before emergence, wetting the soil with irrigation or breaking the crust with a 'millipede implement' will improve emergence.
- Planting is ideal around mid-December.
- A fungicide seed dressing of Thiram 80 WP (85 g/50 kg seed) or Captan 50 WP (125 g/50 kg seed) will help ensure good emergence.
- Soyabeans are particularly sensitive to weed competition during the first six weeks of the season.
- Soyabeans are very susceptible to drought during the pod-filling stage.

Soyabean Planting Guide

Target Harvest Population per ha	Required Planting Population per ha	Required average number of seeds per metre of row				Seeding rate (kg/ha)		
		Row width (m)				Thousand seed weight (g)		
		0.45	0.60	0.75	0.90	250	220	190
200000	248000	11	15	19	22	62	54	47
240000	297000	13	18	22	27	74	65	57
280000	347000	16	21	26	31	87	76	66
320000	396000	18	24	30	36	100	87	75
360000	446000	20	27	33	40	111	98	85
400000	495000	22	30	37	45	124	109	94
440000	545000	25	33	41	49	136	120	104

Soyabean Management Guide

Establishment	Late vegetative, early flowering period	Seed filling
Lime acid soils (Ideal pH=5.3). Fertilise as necessary. Best variety. Use certified seed. Inoculate with Rhizobium. Do not plant too deep. Population: 300,000 plants/ha Row width 45 - 75 cm. Ensure early weed control.	Control any new weed growth. Start scouting for Semi-loopers and Rust. Apply first fungicide spray for Rust at first flower.	Ensure good control of Rust and Semi-loopers. Apply two fungicide sprays during this period. Irrigate when there is a dry spell longer than 5 days. Harvest early to avoid shattering losses

Pests

Semi-looper caterpillars

- Often a problem during the flowering and seed-fill period.
- They eat the leaves and sometimes the pods.
- Normally controlled by a naturally occurring virus disease, which kills the caterpillars. Caterpillars that have died from the disease are black and hang from the leaves. These may be collected, crushed, mixed with water and sprayed around the field to help control other caterpillars.
- If the virus is not killing the semi-loopers then an insecticide spray may be required.

Diseases

Frog Eye Leaf Spot (*Cercospora sojina*)

Most cultivars available today are resistant to this disease.

Rust (*Phakopsora pachyrhizi*).

- The Rust disease may be recognised as numerous small grey to russet coloured tufts on the underside of leaves. They may appear similar to red spider mites.
- In advanced stages the leaves become distinctly yellowy-brown and a light brown cloud of spores are seen in and above the canopy when the plants are shaken.
- It can be controlled using a fungicide spray.
- A number of chemicals are available, such as Punch® Xtra (350 to 500 mL/ha) and Shavit® (500 ml/ha). Two or even three, fungicide sprays are at 3 week intervals beginning at first flower. Ensure good leaf cover when spraying.

Red Leaf Blotch (*Pyrenochaeta glycines*).

- Severe infections can reduce seed yields by 30% - 50%. D.
- Solitaire and Soprano are moderately resistant.
- Chemical control is not available.

Harvesting

a) Hand harvesting.

- Suitable for small areas.

- Advantages of hand harvesting are that:
 - Losses can be reduced to a minimum
 - Soyabeans of a high quality are produced
 - The beans normally have a high viability.
- Therefore, hand harvesting is suitable for seed production.

b) Mowing or cutting by hand and shelling.

- A variation is to use a mower to cut the plant material, and a mechanical winnower for the final cleaning.
- This method should enable an output of ± 150 kg (3 bags)/labour/day. This method enables harvesting to commence before the pods split, but allows sufficient moisture to be lost, thereby preventing mould developing in the established cocks or stacks.

c) Swather plus combine.

- This method involves the use of a swather to cut and wind-row the crop before it is combined. A pick-up attachment is required to be fitted to the combine table.

d) Combine harvesting.

- Large areas are usually reaped by combine harvester and losses are inevitable.
- The degree of loss depends on the efficiency of the machine and operator, evenness of the land, the height of the pods off the ground, lodging, the moisture content of the beans, and weed control.

Sugar Cane Production

Introduction

- Sugar Cane is a long season crop (12 months growing cycle).
- It has a high water requirement of about 1500 mm / yr.
- It thrives well under high temperature conditions (Min.16-21°C and Opt. 27-38°C).
- Hence bulk cultivation of the crop is in Chiredzi and Triangle.

Seed Cane

- Growers are encouraged to plant more than one variety to minimise losses due to pests and diseases.
- Varieties N14, N10 and NCO376 are available.
- Farmers must make arrangements with seed producers to grow seed for them. The ZIMBABWE Sugar Association (ZSC) certifies seed cane producers and no charge is levied for seed production.
- It takes 8-10 months to produce seed cane

Propagation

- Seed cane consists of cuttings with shoots (25-30 cm long) called setts.
- An ideal sett should have at least 2 internodes and at most 3 internodes.
- Number of buds that germinate decrease with an increase in the number of internodes beyond 3. Use of certified seed cane will minimise systematic smut infection.

Planting

- The ideal time is mainly in the later summer months (August- November).
- March and April are also suitable due to the low weed pressure characteristic of the period. The crop results in high sucrose yield because the well grown cane is dried off when conditions are best suited for ripening.
- Sugar cane planted from May to July is generally slow growing due to the very low temperatures characteristic of the period.

Planting procedures

- Generally spacing is 1, 5-1, 8 m inter-row and 0.6 intra-row.
- First sprinkle Bayfidan to the setts to protect against termites
- Plant by laying setts in the furrow. Cover the setts with soil.
- Overlap the setts to an increasing degree if there is any doubt about seed cane quality
- Spray the setts and furrow with Dieldrin solution to protect the crop from Heteronychus Beetle.
- 8-10 tonnes of seed cane are required per ha.
- Failure to germinate may be due to:
 - *Mechanical injury of the buds.
 - *Chemical injury.
 - *Poor nutritive status of the setts.
 - *Lack of nitrogen.
 - *Disease.
 - *Low temperatures expose setts to decay.

Fertilisation

- The ZSA provides soil analysis services to all cane growers.
- The general recommendation is to apply 200 kg/ha MOP, 200 kg/ha SSP and 150 kg/ha AN at planting.
- These fertilisers are put in the furrow and covered with soil before putting the cane /setts
- Generally AN rate is 450 kg/ha. Note that the remainder of AN should be applied before the crop is 12 weeks old.
- For ratoon crops the fertiliser is usually applied in a band shortly after cutting.
- Blends can also be used in sugar cane production and these are a much cheaper option
- Blend 1 - 430 kg/ha
 2 - 620 kg/ha
 3 - 700 kg/ha

Irrigation

- Overhead and furrow irrigation are the common methods of irrigation used in production of sugarcane.
- The average water requirements, from planting to harvesting, is about 16 mega litres of water/ha. This requirement necessitates a peak water requirement of about 70mm a week in hot, dry periods and in winter 2-4 weeks with the same application.

Weed Control

Hand and mechanical weeding can be used, but herbicides are more widely used.

Pre-emergent or early post emergent herbicides

Atrazine 1, 6 l/ha

Alachor 1, 3 l/ha

The crop should be kept weed free at least until it has established an effective canopy.

Pests

***Heteronychus* beetle**

- This is the major pest at present.
- The beetle causes stem and root damage.
- Spray with dieldrin (2, 25 kg in 440 litres water) into the furrow and over the setts before covering. The mixture is enough for one hectare.
- Dieldrin sett dip can also be applied by dipping the setts into the chemical before planting.

Migratory Locust

- Devours cane leaves and this has a bearing on yield since the leaves are photosynthesis sites.
- Spray with cabarayl

Pearly scale

This is controlled by Dieldrin applied for *Heteronychus* control

Diseases

Smut

Is the most serious disease of sugarcane

Can be controlled through use of resistant varieties, use of clean certified seed, general field hygiene and planting material can also be treated with fungicides e.g Tilt

Ratoon stunt

Results in stunted growth and can also seriously reduce yield.

Can be controlled by using hot water treatment in the setts.

Leaf Scald

Controlled by using resistant varieties, e.g. NCO 376, N 14

Quota system

- Currently, in Zimbabwe milling is done at Triangle.
- For commercial production all prospective farmers have to enter into agreement with the milling company on how much cane they propose to deliver on a set date (12 months from planting). The farmer has to estimate the hectareage to be planted, variety and estimate of anticipated yield.

Harvesting

- Sugarcane is cut after being burnt.
- Burning is preferably done at night since temperatures will be slightly lower. This minimises the conversion of sucrose into alcohol.
- Farmers are advised to inform the milling company in advance if they are unable to meet the milling quota agreements in order not to disadvantage other farmers.

NB: There are 203 harvesting days for the year and after the mills will be shut down. On average, a cutter can harvest 0,066 ha/day.

- There are better returns if harvesting is done before the onset of the rainy season.
- For a bundle weighing 5 tonnes and above, a cutter is given a bonus.
- Yield levels are in the range 90-120t/ha.

Transportation

- The time spent between burning of cane and milling should be less than 72 hours in order to minimise the loss of sucrose from the cane.

Management

- If cane is poorly managed and the Plant Protecting Group of ZSE discovers serious pest and disease infestation the crop may be declared useless and will be ploughed out.
- At least 90 days have to be allowed between ploughing out of the cane and introduction of a new crop.

Returns

- Most farmers tend to break even at between 65 - 70t/ha of cane yield.
- Excellent farmers can even go up to between 100 - 120t/ha of cane.

For every 50 tonnes of sugarcane delivered, there is automatic sampling and subsequent filtration of the juice which is done by the laboratory department of the milling companies to determine how much sucrose is in the juice.

Generally, 12% of the cane will be sucrose, i.e. the estimated recoverable crystals will be 12% of the tonnage delivered. The farmer will be paid the remainder after milling and transport costs plus levies that might apply are deducted.

Tobacco

Tobacco: Flue Cured

The Ideal seedling

- Is 15 cm in length from bud to root-crown;
- Is at least as thick as a pencil;
- Has produced not more than eight to ten visible leaves
- Is well –hardened
- Is disease –free, Has a strong root system

Tobacco Seedling Production Using The Float Seedbed System

The float tray system replaced the conventional system on tobacco seedling production following the phase out of Methyl bromide.

Advantages:

- it uses fewer chemicals and in smaller quantities
- it employs economical integrated management of diseases and pests
- it uses less water and fertilizers
- it produces superior and more uniform drought tolerant seedlings
- it offers additional flexibility in planning following pulling
- it facilitates easier field management arising from a more uniform crop
- it has a permanent seedbed site and there is no need for rotations
- trays can last for five or more years if kept properly

Materials Required For One Hectare Worth of Seedlings

	200 Cell Tray	242 Cell Tray
Trays	87	72
Seed number	20 000 pellets	20 000 pellets
Black plastic	39m ²	34m ²
Pine bark	220 litres	Up to 432 litres
Washed river sand	220 litres	108 litres
Water	2060 litres	1700 litres
Ammonium nitrate	600g (22 x cup 30)	800g (18 x 30 cup)
No. of bricks	400	320
Hydrofert	1.6kg	1.3kg
Floatfert	7 litres	6 litres
Dibbler	200 cell dibbler	242 cell dibbler

Site Selection

Choose less level ground

Bed Construction

- Beds should be sufficiently wide to accept three or four floating trays side-by-side.
- This means that the inside dimensions of the retaining float water wall must be approximately 1.05 m wide for three trays and 1.40m for four trays.
- Two courses of farm bricks can be used and may be loose-laid or be set in position permanently with mortar.
- Next the entire construction must be lined with 250 micron black plastic sheeting.

floatfert	200	87	2058	1.01	2.5 l	3.5 l	70. l
	242	72	1700	1.01	2.0 l	3.0 l	6.0 l
Hydrofert	200	87	2058	260g	515g	772	1.6 kg
	242	72	1700	212g	425g	640	1.3 kg

Top Dressing Fertiliser

- At 6 weeks (42 DAS) ammonium nitrate is applied at 100mgN/litre of water as shown in the following table.

Watering

- After the initial bed filling ensure that the water is replenished in beds regularly in order to avoid trays and media drying.
- Good quality water, which is free from nematodes, pathogens, salts and other undesirables, should be used.
- The ideal water pH is between 5.5 and 6.4.

Clipping

The benefits of clipping include;

- ✓ Increased seedling uniformity.
 - ✓ Removal of excess foliage thus allowing the plant canopy to dry.
 - ✓ Regulation of seedling growth.
 - ✓ Hardening of the plant later in the cycle.
 - ✓ Holding the transplant past its due date.
- Clipping should be frequent and light, beginning when the seedlings are about 5 to 7 cm in height.
 - Sanitation is a critical part of clipping therefore plant clippings should be properly disposed of to avoid spread of diseases. The mower or cutter must be thoroughly cleaned and sanitized before and following each use to ensure there is no spread of Tobacco Mosaic Virus (TMV) or other diseases.

Hardening

- Seedlings should be sufficiently hardened so as to survive the difficulty of transplanting under difficult conditions experienced in the lands.
- Hardening is done by ensuring that the seedlings utilize most of the nitrogen early in the growth and that little remains in the water during the last two to three weeks before transplanting
- Clipping also has a hardening effect.
- For further hardening remove the fertilizer solution from the waterbed, and replace the solution with water only for the last week of production.
- The simplest test for “hardness” is that a seedling should be able at least to be bent over without snapping.

Problems and Possible Solutions

Algae Growth:

- Actual harm to the seedlings is unusual..
- Cover as much as possible of the surface water with trays so as to exclude sunlight on water, which encourages algal growth.

- It can also be controlled by delaying the fertilizing of the float bed to 14 days after seeding, this allows the seedlings to germinate and grow above any algal growth on the cell surface.
- Used trays should be washed and sanitized before use. Use of Algaecides is uneconomical.
- Avoid using pine bark/sand mixture in 242 Cell trays as they become heavier and tend to sink thereby creating waterlogged conditions.
- As a preventative measure apply a Quaternary Ammonium Compound (QAC) or copper oxychloride in float water at sowing. Copper oxychloride is applied at the rate of 0.012 g/L and Pentakill at 0.18 ml/L for one hectare of seedbed.

Amount of water(L) in 1 ha bed		Copper oxychloride 85% wp at 10 ppm		Sporekill 12% at 36 ppm		Pentakill 20% at 36 ppm	
Tray type		g	No. 30 cups	ml	No. 30 cups	ml	No. 30 cups
242	1700	20	1.3	508	17	305	10
200	2000	24	1.5	592	20	355	12

2. Pythium root rot

Water amount (L)		Ridomil MZ 68% wp at 5 ppm		Ridomil MZ 68% wp at 10 ppm	
		g	No. 30 cup	g	No. 30 cup
242	1700	212	22.3	424	44.67
200	200	247	26	494	52

3 Sore Shin

- Sore shin in the field is managed by drenching seedlings in the float bed two days before pulling with one of the following fungicides at 1 litre/tray as indicated below:
 - (a) Tridemol
 - Baytan 15% wp at 1.5 g/L/tray
 - Shavit 25% ec at 0.9 ml/L/tray
 - (b) Cyproconazole
 - Alto 100 sl at 0.6 ml/L/tray
 - (c) Triticonazole
 - Premis 200 fs at 1.2 ml/L/tray

	No of trays	Area m ²	Baytan 15% wp 1.5g/tray		Shavit 15% ec 0.9ml/tray		Alto 100sl 0.6ml/tray		Premis 200fs 1.2ml/tray	
			g	No. 30 cup	ml	No. 30 cup	ml	No. 30 cup	ml	No. 30 cup
242	72	16.6	108	8.75	65	2	43	1.5	86	3
200	84	19.4	126	10	75.6	2.5	50.4	1.67	100	3.3

- **Spiral/Aerial Roots:** Thought to be associated with inadequate media aeration (too much water/too little air). Spiral root plants occur when the root of germinating seedlings does not penetrate into the growing media. Plants will either die or lag behind other plants. Avoid packing media too tightly and avoid overhead watering.
- **Dry Cells:** Water fails to move up the cell by a process called “wicking” due to loose compaction of media in cells. No wicking means no germination. Follow the tray filling and handling procedure correctly.
- **Cold injury:** The float beds should not be allowed to get cold. The June sown nurseries need to have both crogard and plastic tent and a greenhouse.
- **Salt Injury:** Greyish salt deposits on substrate surface. Severe cupping of seedling. The possible solution is to water with a knapsack sprayer thoroughly to leach the salts from the surface. Also cover with Crogard or a sterile mulch plus plastic cover at night.
- **Chickens:** These are a pest. Protect seedbed area.
- **Maize Shellers:** maize chuff and dust is detrimental to seedling growth. Ensure float bed site is situated away from maize shellers.

Pests and Diseases

Seedbed diseases (From TRB Recommendations)

DISEASE	SYMPTOMS	CONTROL
<i>Anthraxnose</i> (<i>Collectotricum tabacum</i>) See also disease in lands for <i>altenaria</i> control	Brown lesions on leaves, midribs and stems. Leaf lesions fawn, circular often with darker edge	1. Pre-treatment with Zineb (65% WP at 225g in 15-20 litres of water per 25m bed in dry soil. Water and leave several days before sowing. Sow 10 days before normal date as this treatment retards growth. 2. One of the following weekly; a) Thiram: 80% WP 150-250g/100 litres water b) Dithane M 45: 80% WP 100-150g/100 litres water. Commence when plants are 10mm in diameter. Application rate: 5 litres/25m ² increasing to 115-20 litres/25m ² c) Start spraying 222-3 wks after germination. Anilazine 50% WP 195-375g/100l water 75% WP 130-250g/100l water 3. If disease appears use 400-800ml/m ² Benomyl at 220g/100l water.
Wild fire (<i>Pseudomonas tabacum</i>)	Circular brown lesions with a halo round each	Copper oxy-chloride or oxy-sulphate at 300g WP containing 50% copper in 100 litres water, applied at rate of 200ml/m ² weekly
Angular Leaf sport <i>Pseudomonas angular</i> Frogeye <i>Cercospora nicotiane</i>	Irregular, usually small, angular dark lesions on leaves and stems Brown circular spots with greyish centres on leaves. Brown lesions on stem with white centres.	As preventative spray, use same chemical, 300g/100 litres water, applied at rate of 200ml/m ² weekly Spray at 2.4 to 4.8 bar pressure, each nozzle delivering 850-2300ml/min. For full details refer to TRB handbook.

Note: - **Do not mix fungicides with insecticides**

Cutworms and ants

- Apply a coarse spray of 135g Neotox sp in 100 litres water at a rate of 200ml/m² or drench with 65g/100 l at rate of 1.5 l/m²

Aphids

- There should be no treatment within four weeks of germination.
- Neotox or Monocrotophos 40%WSC, 120ml/100 l water will control aphids. For specific aphid control drench at the rate of 1 l/m² or spray 500ml/m² every 2 wks.
- Alternatively, drench or spray beds at the following rates every two wks with one of the following insecticides:

Insecticides	Ml/100 litres water	
	Drench	Spray
Dementon-S-Methyl 25% EC	150	300
Dimethoate 40% EC	190	380
Repeat one or two days before pulling		

Planting

Single Row System								
Row Spacing	40cm	43cm	46cm	49cm	52cm	55cm	58cm	60cm
100cm	25 000	23 256	21 739	20 408	19 231	18 182	17 241	16 667
105cm	23 810	22 148	20 704	19 436	18 315	17 316	16 420	15 873
110cm	22 727	21 142	19 763	18 553	17 483	16 529	15 674	15 152
115cm	21 739	20 222	18 904	17 746	16 722	15 810	14 992	14 493
120cm	20 833	19 380	18 116	17 007	16 026	15 152	14 368	13 889
125cm	20 000	18 605	17 391	16 327	15 385	14 545	13 793	13 333
130cm	19 231	17 889	16 722	15 699	14 798	13 986	13 263	12 821

Twin Row System

Twin Row	Working row	Plant spacing					
		43cm	46cm	49cm	52cm	55cm	60cm
90cm	125cm	21 633	20 222	18 984	17 889	16 913	15 504
90cm	130cm	21 142	19 763	18 553	17 483	16 529	15 152
90cm	140cm	20 222	18 904	17 746	16 722	15 810	14 493
100cm	120cm	21 142	19 763	18 553	17 483	16 529	15 152
100cm	130cm	20 222	18 904	17 746	16 722	15 810	14 493
100cm	140cm	19 380	18 116	17 007	16 026	15 152	13 889
110cm	120cm	20 222	18 904	17 746	16 722	15 810	14 493
110cm	130cm	19 380	18 116	17 007	16 026	15 152	13 889
110cm	140cm	18 605	17 391	16 327	15 385	14 545	13 333

Summary of planting methods

Method detail	Buckets and cups	Water cart 4 horses	Water cart 6 horses	Boom with 4 horses	Parallel Feed line And	Hoses From Standpipe

					irrigation	irrigation
Land size Hectares		9	9	9	3	5,8
Plant pop Per ha	15 151	15 151	15 151	15 151	15 151	15 151
Total plant stations	136 359	136 359	136 359	136 35	45 453	87 826
Period of planting (hrs)	24	38,30	25,25	37,10	8	8
Period of planting (days)	3	4,79	3,45	4,64	1	1
Required output per hr	5 681	-	-	-	-	-
Output per hours of team at 75% of standard No. of plants per hr.	740	3 560	5 400	3 675	5 660	10 833
Teams required	8	1	1	1	1	1
LABOUR						
Watering labour	16	2	3	2	3	4
Boom carriers	-	-	1	2	-	-
Planters	8	4	6	4	6	12
Planters waiters	8	4	6	4	6	12
Plant supply labour	2	1	2	1	2	4
Drum labour	4	-	-	-	-	-
Main hose attendant	-	-1	3	-	-	-
Pump attendant	-	-	-	1	-	-
Spare	4	2	3	2	2	4
Foreman planting	1	1	1	1	1	1
Covering labour	6	3	5	3	6	12
Cutworm treatment labour	8	4	6	4	6	12
Foreman covering in and cutworm treatment	1	1	1	1	1	1
Sub-total	54	20	33	26	31	58
Drivers	2	2	2	2	-	-
Seedling labour at 930 seedlings/hr	7	4	7	4	7	13
Total Labour	63	26	42	32	38	71
Labour days per ha at 75% of standard	22.33	14.89	15.63	16.49	13.33	12.93

Insect control (Lands)

Routine spray I: (Cutworms, Leaf eaters, Leaf miner, millipedes, budworm, Aphids)

One of the following insecticides should be applied in a 30 cm swath directly over the plants using 500 litres/ha and minimal spraying pressures to ensure maximum run-off and plant wetting:

Cypermethrin 20 % EC, 50 ml/100 litres water

Decamethrin 2.5 % EC, 120 ml/100 litres water

Application

- Using a knapsack sprayer fitted with an ES 12-80 degree or 8015 nozzle at 1-1.5 bar pressure and traversing the row at 1m/sec will apply approximately the correct volume (3.6litres/m). The knapsack sprayer will have to be refilled every few minutes.
- Tractor mounted boom: treat two rows at a time with nozzle outlets directly above the row centres. An alternative is a spray boom with four to six hand held spray laces.
- Calibration: To obtain large droplets for maximum plant wetting and run-off, low spraying pressures (1.0-1.5 bar) must be used.
 - i. Select a suitable tractor speed
 - ii. Select correct nozzle size to give 500 litres/ha in 30 cm band over ridge
 - iii. If nozzle is limited, select suitable tractor speed.

Routine Spray II

- Use same equipment as for Routine Spray I where plants are about to enter their main growth phase. A high clearance tractor will reduce plant damage. This second spray is intended to function with Routine Spray I.

Disease Control (Lands)

DISEASE	DESCRIPTION	CONTROL
White Mould (Erysiphe)	Powdery white spots on both surfaces of lower leaves which gradually move up the leaves	Dinocap 25% WP, (Karathane 20% WP) 400-800g/ha + 20ml wetting agent Benomyl (Benlate 50% WP); 200g/ha + 20ml wetting agent
Wildfire, Angular Leaf Spot	Small lesions, surrounded by green halo, older lesions have brown center and surrounded by yellow halo	None. Resistant varieties
Anthrachnose, Frogeye	Circular white lesions, surrounded by brown necrotic rings and small yellow haloes	Benomyl (Benlate 50% WP), 200g/ha + 20ml wetting agent Iprodione (Rovral 250 sc, 2litres/ha
Alternaria leaf spot	Brown necrotic lesions with concentric rings surrounded by a yellow halo on leaves and elongated on stems.	tebconazole (Folicur 250 ec, 500ml/ha Iprodione (Rovral 250 sc, 2 litre/ha
Soreshin	Decay of stalk below soil level	Drench seedbeds with Baytan 15% wp 2 days before pulling
Black Shank	Wilting in field and yellowing of bottom leaves. Base of stem blackened and if split longitudinally pith is laddered	Propamocarb-HCL (Previcure N), 60 ml/litre water Metalaxyl 68 MZ (Ridomil 68 MZ), 200g/litre of water
Mosaic	Dark green and chlorotic light green areas on leaves.	Resistant cultivars plus sanitation

	Also curling, mottling, distortion and blistering of leaves plus dwarfing of plant	
Rosette and Bushy Top	Mottling of leaves and vein distortion leading to backward and downward curling of leaves. Plants look bushy because of excessive growth of side shoots.	Transmitted by aphids
Leaf Curl	Veins thicken on lower leaf	Transmitted by whitefly

- Cutworm infestation, early and late: keep land free from weeds for at least a month before planting.
- Apply the material as a drench to wet the soil round the base of the plant, using up to two 30 fertiliser cups per plant.

Output per hour per labourer treating plants against cutworms:

Level of productivity- % of standard	100	90	80	75	70	60
Plants per hour per labourer	1 060	955	850	795	740	635

For planning purposes use figures below 75% of standard. Outputs may be halved if two applications per plant are required (late infestation)

Aphids:

- Granules: Disulfoton 5% granules at 45kg/ha (3g/plant) or Menazone granules at 90 kg/ha (6g/plant)

Sprays:

- Dementon-s-methyl 50% e.c 150 ml/100litre water, Dimethoate 40% ec 375ml/100 litres water, Menazon 70% DP 300g/100 litres water
- Apply to Dec and Jan plantings at weekly intervals for three weeks, starting one week after planting.
- Rate of application is 200 litres/ha. Add 33 % more active ingredient/ha for aerial spraying.

Budworms:

- Can be controlled by hand picking, but this should not be attempted where mosaic is troublesome. If hand picking cannot restrict the infestation to 10 caterpillars per 100 plants or less spray with:
- Acephate 75% sp 90g/100 litres water: Monocrotophos 40% sp, 110/100 litres water
- Methamidophos –40% wsc, 350/100 litres water
- Penetration of bud is essential. High volume application- 250 litre/ha, through flat fan nozzle – minimum pressure three bars, held 15 cm above heart of plant e.g.

application will be achieved with FS8 or 504 nozzle, moving along the row at 1m/sec.

Crickets:

- Use discarded seedlings dipped in either Trichlorform 95% sp-10g/100 litres water. Distribute the treated seedlings or maize meal bait in the late afternoon, especially near obvious cricket holes.

Lace worms:

- Control by hand –picking but when more than eight worm/100 plants spray using Methomyl 90% sp, 333g/ha.

Leaf Miners;

- Monocrotophos –40 % wsc, 190m/100 litres water. Apply over plants-small plants 150 litre/ha and large plants 3000 litre/ha
- Three applications at weekly intervals will be required to eradicate severe infestations.

Lesser armyworm:

- Spray Acephate 75% sp-180g/100 litre water or;
- Methomyl 90% sp – 110g/100 litre water

Stinkbugs and loopers;

- Hand picking is usually sufficient. Severe infestations spray Monocrotophos –40 % wsc, 800 ml/ha.

White grubs and False wireworms:

- Can be controlled culturally by early ploughing, planting and grass rotations.
- Where they are troublesome, apply Chlorpyrifos –48% ec in planting water at minimum of 500 ml/plant. For one ha at 115 000 plants/ha, require 50 ml of the concentrate.

Topping and Suckering

By hand

Topping plants in bud stage, one row at a time.

% to be topped	Level of productivity-%of standard metres of ridge per labourer in eight hours.					
	100%	90%	80%	75%	70%	60%
10	27 100	24 400	21 700	20 300	18 950	16 250
20	21 900	19 700	17 500	16 400	15 300	13 150
30	18 600	16 750	14 900	13 940	13 000	11 150
40	15 900	14 300	13 700	11 900	22 250	9 550
50	14 050	12 650	11 250	10 550	9 850	8 450
60	12 400	11 150	9 900	9 300	8 700	7 450
70	11 100	10 000	9 000	8 350	7 800	6 000
80	10 000	9 000	8 000	7 500	7 000	6 650
90	9 250	8 350	7 400	6 950	6 500	5 550
100	8 500	7 700	6 850	6 400	6 000	5 150

Output for various methods of applying suckercide

Method of application	Level of productivity-% standard					
	100%	90%	80%	75%	70%	

To two leaves in a split application from one measure cup	865	780	690	650	605	520
With tipping bottle (Kurt type applicator)	915	825	730	685	640	550
With measuring cup in one application over top of stem	1 015	915	810	760	710	610
From bottle with plunger	1 020	920	815	765	710	610
With handgun(Manipular, windmill etc	1 020	920	815	765	715	610
With boom, handgun and tractor equipment	850	725	645	605	565	485

For planning purposes always use figures below 75% of stem card

Reaping

Tying methods

- Single strings: untying slow unless the string is cut. If cut, use expendable string (expensive)
- Double string-over stick: causes most damage and fallout.
- Double string under stick, horizontal and vertical string hanging: causes less damage, use re-usable string.
- Tilita clips; minimum damage and fall out, but untying is slow.
- Manipular clips; untying is fast. Possible damage or breakage of large mid-ribs.

Information on string

String	M/kg	Breaking strain kg	Finish	Comments
T1	623	25	Glazed	Sold in spools of 500g and 2.5kg. Normally used for sewing bales. When use a substitute for T2 it unravels badly on reuse
T2	364	27	Glazed	Sold in spools of 500g and 2.5kg. Commonly used for and horizontal string hanging of tobacco in the barn
T9	1 260	7	Unglazed	Sold in spools of 500g only. Most commonly used with sticks. Too weak for horizontal hanging of tobacco in barns. Normally cut when untying, but can be re used
T22	648	20	Unglazed	Sold in spools of 500g only. Suitable for horizontal hanging and re- use. Better than T12.
T13	296	11	Glazed	Sold in spools of 500g only. Normally used with Oriental Tobacco
T410	3 940	3	Unglazed	May cut too much with single string tying
T480	738	14	Unglazed	Expensive compared with T22

Outputs

- **Kurt machine, using string**

Output per reaper per hour at 75% of standard, 102 leaves per string

Position on plant	Average number of leaves per plant					
	0.5	1.0	1.5	2.0	2.5	3.0
Bottom	9	11	13	13	14	15
Middle	12	16	17	18	19	19
Top	13	16	17	18	19	19

With a proper land layout (including parallel), it should be possible for two reapers to share one waiter.

- **Short clips**

Output per reaper per hour at 75% of standard 45 leaves per clip.

Position on plant	Average number of leaves per plant					
	0.5	1.0	1.5	2.0	2.5	3.0
Bottom	16	24	31	36	39	39
Middle	17	27	32	37	39	39
Top	19	29	34	38	40	40

With proper layout, it should be possible for two reapers to share one waiter

Position on plant	Average number of leaves per plant					
	0.5	1.0	1.5	2.0	2.5	3.0
Bottom	13	14	16	16	17	17
Middle	16	17	18	19	19	19
Top	19	20	21	23	24	24

Allow one waiter for every two reapers.

Traditional reaping (for bulk curers)

- The output per reaper in bundles per hour at 75% of standard is 102 leaves per bundle or equivalent.

Position on plant	Average number of leaves per plant					
	0.5	1.0	1.5	2.0	2.5	3.0
Bottom	8	16	20	24	25	28
Middle	8	16	21	27	29	31
Top	11	22	28	32	34	34

- Allow one waiter for every reaper.
- Barns; Barn to land ratio for standard barns, at least on 5m x 5m x 8 Tiers for every 1.5 –2.0 ha

Rule of thumb: allow one standard barn (5m x 5m x 8 tiers) per day for every 10 hectare of tobacco grown. A 40 hectare crop will require 6 x 4 = 24 barns if barn turn round time is seven days.

Barn spacing and capacities

Barn size	No. bays	Spacing between strings, clips or sticks	Tiers per barn			
			7	8	9	10

Strings or sticks						
5m x 5m	4	200mm	700	800	900	1 000
5m x 6m	4	200mm	840	960	1 080	1 200
6m x 5m	5	200mm	875	1 000	1 125	1 250
6m x 6m	5	200mm	1 050	1 200	1 350	1 500
Long clips						
5m x 5m	5	200mm	875	1 000	1 125	1 250
5m x 6m	5	200mm	1 050	1 200	1 350	1 500
6m x 5m	6	200mm	1 050	1 200	1 350	1 500
6m x 6m	6	200mm	1 260	1 400	1 600	1 800
Strings or sticks						
5m x 5m	4	225mm	616	704	792	880
5m x 6m	4	225mm	728	832	936	1 040
6m x 5m	5	225mm	770	880	990	1 100
6m x 6m	5	225mm	910	1 040	1 170	1 300
Long clips						
5m x 5m	5	225mm	710	880	990	1 100
5m x 6m	5	225mm	910	1 040	1 170	1 300
6m x 5m	6	225mm	924	1 056	1 188	1 320
6m x 6m	6	225mm	1 092	1 248	1 404	1 560
Long clips, stagger packer						
5m x 5m	5	175mm	980	1 120	1 260	1 400
5m x 6m	5	175mm	1 190	1 360	1 530	1 700
6m x 5m	6	175mm	1 176	1 344	1 521	1 680
6m x 6m	6	175mm	1 428	1 632	1 836	1 040
Vertical string	5 per stick	2 layers		3 layers		
5m x 5m	4	300mm	640		960	
5m x 6m	4	300mm	800		1 200	
6m x 5m	5	300mm	800		1 200	
6m x 6m	5	300mm	1 000		1 500	

Summary of barn loading methods

Method	Minimum labour per team For 8 tier barn	Output per team per hour Based on packer (75% of Standard)
Horizontal string and Rope method	Packer + 2 labourers. A Balanced team consists of 2 packers and 3 waiters at 280 strings/hr per team	140

Horizontal string, hand To hand	P + 5	260
Horizontal string and conduit	P + 3	300
Vertical string and rope Method	P + 2	155
Vertical string, hand to hand	P + 3	390
Long clips, hand to hand	P + 5	330 output can be increased to 480 if intermediate labour assists with packing
Sticks and double short clips, hand to hand	P + 5	320 see also above
Loading trailer for bulk Curer	Loading press in land + 3 labourers. Loading trailer in Land = 2 labourers	Loading bulk curer. Driver + 2 general workers. Time to load bulk curers: 75 – 95 min depending on method

CURING LABOUR

Barns, hand stoked : 10 – 12 barns per labourer
 Barns, auto stoked : 15 – 18 barns per labourer
 Tunnel, Chongololo, bulk : 1 labourer per shift. Trolleys may be moved at shift
 Change-over time so that two workers are available
 for moving trolleys.

Coal consumption

Hand stoked; 3 kg coal to 1 kg cured tobacco
 Heat exchanger; 1.25kg coal to 1 kg cured tobacco

Wood furnaces hand stoked. Allow 3 m³/100 kg of cured tobacco

Summary of barn unloading method

Method	Minimum labour per team For 8 tier barn	Output per team per hour Based on packer (75% of Standard
Horizontal string and Rope method, 5 strings per Occasion	Unloader + 1 final passer + Waiters or trolley 2 labourers are needed to load The trolley	430
Vertical string, rope method, 5 strings per occasion	U + 1 plus waiters or trolley	660
Sticks or clips, hand to hand	U + 3 plus waiters. Only one worker needed to load trolley if used	530
Clips from tunnel trolley, Hand to hand	3 labourers in team at 810 clips per hour per team	810
Unloading bulk curer (including transport)	Team of three + one cleaning fallen leaves	Time per curer of 1162 trays = 90 min

Final Operations

The following figures may be used as a guide. All outputs at 75% of standard:

Unclipping long talita clips 115 clips/ha/lab.
 Unclipping short talita clips 130 clips/ha/lab
 Unclipping manipular clips 190 clips/ha/lab.

Untying reusable string

120 strings/ha/lab/

- Unclip and temporary store contents, 110 min for team of two for team of two for 162 bulk curer trays.

String bulking; two labourers can place 260 strings/hr. Slate packing; two labourers can place 225 strings or equivalent in bundles per hour including pressing and bale moving.

BULKING

Rough bales

Average size in mm; 900 x 600 x 600.

Maximum mass; 50 – 55 kg for lugs and primings

55 – 60 kg for cutters

60 – 70 kg for leaf

- Rough bales should not be stored more than three deep and should be turned at regular intervals. Space requirements 350 kg/m².
- Loose leaf bulks; not higher than 2 m settled height
- Allow 200 – 250 kg/m², exclusive of pathway

Stick bulks

Temporary; 15 m² per 1000 sticks

Permanent; 120 – 150 kg/m² for bulks 3.5m high.

Slate packs; 600 mm square pack holds +- 45kg

750mm square pack holds +- 67.5kg

When packed five deep, allow 625 kg/m²

Clip bulks (775 mm clips); allow 140 – 150 clips/m²

Grading

- Allow approximately 100 grading days for the crop. One grader can grade at least 50 kg of tobacco a day.
- Up to twice as much tobacco may be graded off the string. Allow one ‘check – waiter’ for every five graders. Have one ‘Super check’ or Master Grader.
- As a rough guide use half the number of labourers for tying as there are graders. Include a leaf issuer, conditioning labourer, boiler attendant and the labourer working on the bulks. It may be necessary to have a sweeper to keep the shade clean. The output of a shade must be in excess of 20 kg per day per person involved.
- A grader can handle between 7 500 and 10 000 leaves per day.
- A baling team consists of three labourers who can bale and sew two to three bales per hour.
- The flow through the shade must be logical and continuous. Use as few grades as possible. To calculate the output of a grader uses the following formula:

$$\frac{7\ 500}{\text{No. of leaves per kg}} = \text{kg/grader/day}$$

- Crop uniformity and the facility with which tobacco may be graded are determined by many managerial factors. Thus land selection, preparation, fertilizing, planting, reaping, curing and storage, all contribute towards the relative ease, or otherwise, of grading.
- Leaf from different lands, different reapings and different barns should be kept separate.

Grades

- The farmer should keep the number of grades down to a minimum of twelve to fifteen.
- “Sample grading” by the farmer should be done daily.

Each leaf should be graded according to the following criteria:

Leaf type	colour	factor	quality	length
Primings	White	Clean	(degree of factor, waste or injury)	Short or long (may be done by check grader)
Lugs	Lemon	Black guinea fowl Green Guinea fowl Spot (Do not mix) Ponge Slate	1. good to fair 2. fair to medium 3. balance	
Leaf	Orange	Water stain Harsh		See tying below
Tips	Mahogany	High maturity Open grained Close grained Slick Greenish Slightly discoloured (Bad barn rot should be stripped)		
	Green			

Tying hands

- Tolerance for leaf length in a hand.
- Where the leaf length is less than 400 mm, not more than 75 mm variation of leaf lengths within the hand is permitted. Where leaf length is over 400 mm, not more than 125 mm variation in length is permitted.

Butt diameter; This may vary between 25 mm and 28 mm, whilst binder measurements may vary between 37 mm and 43 mm from the butt.

Output; 85 hands/ tyer/ hour.

Loose leaf; Growers may present their tobacco for sale in loose leaf form, subject to the following provisions;

- the tobacco must be properly graded
- the leaves must be straight laid and unbroken
- Burley tobacco leaves must be under 230 mm in length
- The length variation within the bale must not exceed 75mm for leaf under 400mm, and 125mm for leaf over 400mm.

Baling

Baling boxes; internal measurements should be 860 mm x 610 mm.

- Bale height; all +/- 30 mm height of bale for every five kg of tobacco, depending on leaf type.
- Bale markings; Numerals to be 75 mm high, except where the bale mass is less than 30 kg when 50 mm high numerals are acceptable.
- Bale mass; Minimum 25 kg; maximum 110 kg nett, or 27 kg to 112 kg gross

Wrapping materials;

- Hessian; Length of material: (Where one piece used; 2.8m, Where two pieces used; 1.4m per piece; Width of material: 1.35 m: Mass of material: 340 g/m²: Waterproof paper: Mass per roll = 17.2 kg)
- Where used, identify with a black cross, marked from corner to corner, on the lot number ticket sewn to the side of the bale, so that the tare mass may be adjusted by the floors.
- Polythene sheet: alternative to paper, minimum thickness; 150 micrometer.

Baling output:

- 10 minutes per team of two for 25 kg bale
- 14 minutes per team of two for 50 kg bale
- 20 minutes per team of two for 90 kg bale
- 24 minutes per team of two for 120 kg bale
- Steam: steam pressure should be 1.7 bars – 2.8 bars for conditioning
- **Sewing output;**
- 28 minutes per sewer per bale of 61 – 120 kg
- 25 minutes per sewer per bale of 31 – 60 kg
- 23 minutes per sewer per bale of 25 –30 kg

Grading Shed requirements

- Grading table should be 1.8m across x 1.2m or 4.5 m²of floor area per grader and the optimum working height when standing should be 93 cm above ground.
- Check grading trolley should be 0.9 m across x 0.6 m x 0.9 m.
- Blending table should be 2 m x 1.2 m.
- Grade boxes should be 1.2 m x 1.2 m for each tyer.
- Baling area should be 35 m².
- Bale store should be 150 kg/m² excluding passages.
- Allow 450 mm for people sitting or standing beside tables, or 300 mm in the case of cut-out tables.
- Passages must be wide enough to allow free movement (i.e. trolleys)

Shed Lighting

- The ideal requirement is 400 lux at the grading surface (although a minimum of 250 lux is acceptable)

Natural light: South facing is best. 15% of roof should be transparent over the grading areas and 10% over the areas. Even light distribution is best achieved by using small roof-light sheets.

Artificial light

Fitting: Single 1.2 m power factor correct industrial fitting with reflector

Type: 1.2 m, 40 watt fluorescent colour matching or north light tube of British manufacture or daylight No. 55 or 57 of Continental manufacture.

Mounting height: Mount fittings, 1.2 m above grading tables, grade boxes and wherever final inspection is carried out. Over other areas mount at 2.9 m above floor.

Spacing: A 1.2 m 40 watt tube gives 250 lux over an area of 1.5 m x 1.2 m. A 1.5 m 80 watt tube at 1.8 m above table covers 2.4 x 1.5 m. N.B When using artificial light, black out all natural light.

Maintenance: Wipe reflectors and tubes daily. When tubes begin to fail, replace all tubes in one area. Re-use those that are still operational in the general lighting area.

Relationship between crop size and grading area for flue cured tobacco

Possible factors leading to yield reduction

Crop stage	Timing	Remarks
Germination	0 – 7 days	
Planting out	8 – 12 weeks	Optimum time 20 th October to 10 th November. Yield loss/week from 10 th - 30 th Nov = 3.5%, thereafter = 7%/week
Weeding	Critical time 4 – 6 weeks after planting	In wet years poor weed control at this stage can lead to 40% reduction in yield In dry years similar reduction can occur through over cultivation
Topping	8 – 10 weeks after planting	Delays reduce yield 5 – 8% per week and will affect grade
Reaping		If lower one third of plant colours in 48 – 72 hours+, reaping is ripe. If top two thirds of plant colours in 36 – 48 hours +, reaping is ripe. If colouring takes place in less time, this indicates over-ripe reaping and can lead to a 6% loss in mass per day for every day over ripe.
Curing		Weight loss of 10% per day over 7 days of cure

Marketing

General information on graders

A grade mark consists of 3, 4 or five symbols. The first indicates the position on the plant, strip or scrap.

i.e P -Primings

X -Lugs

L -Leaf

T - Tips

A -Strips

B -Scrap

The second indicates the quality; 1 – 5 for P, X, L and 1 - 3 for T, A, B. the third symbol indicates the colour i.e.

L - Lemon

E - Pale lemon

O - Orange

R -Light mahogany

S -Dark mahogany

D -Walnut

The fourth and fifth symbols are extra factors which are sometimes added i.e.

A -Spot
 D -Droughted (harsh)
 F -High maturity
 G -Green
 J -Water stained thin
 K - Sub standard (variegated)

O -Scotched
 V -Greenish
 W -Waterstained
 Y -Guinea fowl spot
 Z -Slick

Other marks

If the bale is not sold these marks show the reason why:

MR -Mixed hand
 BMR -Mixed leaves
 BGR -Badly handled
 LR -Mouldy
 HR -Funked
 U -Unsound

NG -No grade
 SR -Stem rot
 NDR -Undeclared split
 RR -Rejected
 NR -No sale
 DR -Damaged

Selling expenses (one bale = 90 kg)

- handling fee of 40 cents per bale
- three percent commission
- Levy 0.72 c/kg + 0.72 percent of value

Hail and Wind Insurance

Consult ZTA, Jupiter etc

Summary of labour days and fuel inputs –flue cured tobacco production

	Standard	Mammoth
Plant population	15 000	15 000
Av. No. leaves per plant	18	21
Reaping period	9 weeks	11 weeks

Basic operations: all figures at 75% of standard

Operation	Dryland		Irrigated	
	Labour days per ha	Fuel – litres/ha	Labour days per ha	Fuel – litres/ha
Seedbeds (D + 20)	25.95	0.75	25.95	0.75
Apply lime (D + 2)	0.34	3.00	0.34	3.00
Plough (D)	0.34	26.00	0.34	26.00
Disc (D)	0.28	9.50	0.28	9.50
Herbicide and disc (D + 1)	0.28	6.00	0.28	6.00
Ridge, fertilise and fumigate single row (D + 2)	0.74	15.00	0.74	15.00
Hole plant stations (F + 12)	1.57	0.25	1.57	0.25
Planting, water cart with 6 hoses (D+F+19)	19.37	20.00	19.37	20.00
Reridging (x2)(D)	0.46	22.00	0.46	22.00
Cultivate by hand (x2) (F+15)	8.35	0.50	8.35	0.50

Topdressing (min x2)(F+12)	14.77	0.50	14.77	0.50
Pest and disease control (C+4)	4.80	3.00	4.80	3.00
Budworm control (C+12)	2.71	0.50	2.71	0.50
Topping (single row)(F+6)(min 3 occ)	1.24	0.75	1.24	0.75
Apply suckercide (F+6)	2.86	0.25	2.86	0.25
Irrigation (C+6)	-	-	10.00	4.50
Remove stalks by hand (F+12)	3.33	0.25	3.33	0.25
Disc regrowth (D)	0.28	9.50	0.28	9.50
Sow grass (D+2)	0.34	3.00	0.34	3.00
Cover seed (D)	0.26	6.00	0.26	6.00
Commuting	-	4.00	-	4.00
Total basic at 75%	88.27	130.75	98.27	135.25

Allow 20l Fuel/ha for harvesting all methods.

Summary of labour days input – Flue cured tobacco production

Harvesting

Operation	Labour days per hectare			
	Standard variety (9 weeks)		Mammoth variety (11 weeks)	
	Reapers to waiters		Reapers to waiters	
	2:1	1:1	2:1	1:1
Reaping for stadard barns using:	based on	100 000	leaves per barn	
Strings	39.03	51.95	43.67	58.27
Long clips	43.24	57.56	48.01	64.03
Short clips	36.00	48.16	40.16	53.49
Sticks	-	72.02	-	80.73
Reaping for chongololos using:	Based on	120 000	Leaves/barn	
Strings	37.77	48.61	41.99	53.35
Long clips	45.77	60.93	50.83	67.68
Short clips	41.84	53.35	46.61	59.25
Reaping for tunnels	Based on	140 000	Leaves/barn	
Long clips	45.35	58.27	50.40	64.87
Reaping for Tilden and mechanical batch curers	Based on	140 000	Leaves/barn	
Long clips	45.49	60.65	50.55	67.39
Reaping for standard long low, using:	Based on	140 000	Leaves/barn	
Strings	36.92	40.29	43.11	54.89
Long clips	45.07	60.23	50.12	66.83
Short clips	37.77	50.40	41.99	55.73
Reaping for bulk curer using trays	-	33.28	-	36.92

For budgetary purposes add 10% for contingencies to any of the above figures

Summary of labour days and fuel inputs – flue cured tobacco production

Operation	Labour days per ha		Fuel litres per ha	
	Standard varieties	Mammoth	Standard varieties	Mammoth
Loading standard barns using:				
Chongololo using (i) Rope	6.17	8.13		
String –hand to hand	9.55	12.49		
Conduit with string	5.75	7.57	20.25	24.75
Long clips hand to hand	4.63	5.89		
Short clips hand to hand	7.44	9.68		
Sticks hand to hand	6.45	8.56		
Long low barns				
Rope with string	6.03	7.72		
Hand to hand with string	9.12	11.77	20.25	24.75
Conduit with string	5.61	7.16		
Long clip hand to hand	5.61	7.16		
Tilden batch				
Long clips hand to hand	5.33	6.60	20.25	24.75
Mechanical batch				
Long clips, hand to hand	5.33	6.60	20.25	24.75
Tunnel				
Long clips on trolleys	5.33	6.60	20.25	24.75
Bulk curers trays	0.99	1.12	20.25	24.75

Summary of Labour Day input – Flue cured tobacco production

Curing

Operation	Standard varieties	Mammoth
Standard barns		
Hand stoked	10.80	13.20
Auto stocked	7.20	8.00
Long lows		
Hand stoked	16.13	19.87
Auto stocked	10.80	13.20
Chongololo(long low or standard)		
Tunnel bulk and batch curers	5.47	6.67

For budgetary purposes add 10% for contingencies to any of the above figures

Summary of Labour Day input – flue cured tobacco production

Unloading and untying

Operation	Labour days per hectare					
	Standard varieties			Mammoth varieties		
	Unloading	Untying	Total	Unloading	Untying	Total

Standard barns						
I. strings	0.61	12.96	13.75	0.81	16.27	17.08
ii. long clips	1.72	4.63	6.35	2.27	5.89	8.16
iii. short clips	1.87	5.95	7.82	2.43	7.75	10.18
iv. sticks	0.97	1.93	2.90	1.28	2.57	3.85
Chongololo						
I. strings	0.61	12.35	12.96	0.81	16.27	17.08
ii. long clips	1.72	5.75	7.47	2.27	7.57	9.84
iii. short clips	1.83	5.84	7.67	2.43	7.57	10.18
Long low barn						
I. strings	0.60	12.65	12.65	0.77	15.44	16.21
ii. long clips	1.68	5.61	5.61	2.51	7.16	9.31
Tilden batch						
Long clips	0.96	2.24	3.20	1.45	2.64	4.09
Mechanical batch clips	0.96	2.24	3.20	1.45	2.64	4.09
Tunnel long clips	0.96	2.24	3.20	1.45	2.64	4.09
Bulk curer trays	0.25	-	0.25	0.28	-	0.28

For budgetary purposes add 10% for contingencies to any of the above figures

Summary of Labour Day input – flue cured tobacco production

Bulking/slate packing

Operation	Yield			
	1 600 kg	2 000 kg	2 500kg	3 000 kg
Rough baling (includes sowing)	3.20	4.0	4.93	6.0
Slate packing				
I. using 70kg packs	2.24	2.88	3.52	4.32
ii. using 45kg packs	3.73	4.80	5.87	7.20
String bulking	Standard varieties		Mammoth varieties	
Loose leaf bulking				
Standard barns				
i. strings or sticks	2.47		3.25	
ii. long clips	3.24		4.12	
iii. short clips	5.59		7.27	
Chongololo				
i. strings or sticks	2.47		2.35	
ii. long clips	3.21		4.24	
iii. short clips	5.47		7.27	
Long-lows				
i. string	2.41		3.09	
ii. long clips	3.15		4.01	
Tilden/mechanical batch				
i. long clips	4.27		5.28	
Tunnel				
i. long clips	3.31		4.09	
Bulk curer				
Trays	1.79		2.93	

For budgetary purposes add 10% for contingencies to any of the above figures

Summary of Labour Day input – flue cured tobacco production

Grading, including tying, sewing and despatch (based on yield)

Operation	Labour days per hectare based on yield			
	1 600	2 000	2 500	3 000
Grade ,tie, sew, bale and dispatch	71.33	72.8	84.26	84.26

Cassava

Scientific name: *Manihot esculenta* Crantz

Shona name: mufarinya, mujumbura

Ndebele: Umjumbula

Climatic requirements

- Cassava is a drought tolerant starchy, root crop which yields well under marginal conditions.
- It grows well in areas with an annual well distributed rainfall of 750 – 1000 mm but can tolerate low rainfall.
- It prefers high temperatures of 25- 29°C.

Soil requirements

- Performs best in deep well drained, light textured soils of intermediate fertility.
- Has high tolerance to acidity and optimum pH is between 4.5 and 6.5

Seed

- It is propagated from stem cuttings

Seed rates

- A plant population of 10 000 plants per hectare is economic and gives a good crop
- . Stem cuttings for seed should be 25 – 30 cm long i.e. 5-7 nodes

Spacing and depth of planting

- It is planted on ridges about 1m apart but may be planted on flat land in deep sand soils..
- Spacing is 80- 100 cm within and between ridges.
- 2/3 of the cutting must be buried in the ground and the remaining part exposed above the ground.

Soil fertility and fertilizer management

- Applied 300kg/h of Compound C (6:17:15).
- Optimum N application is 60kg/ha .

Yield potential

- High yielding improved varieties can yield up to 50t/ha (fresh weight)..

Weed management and Control

It requires 2 hand weeding. First at 3-4weeks and then at 7-8 weeks after planting.

Diseases

- Cassava Mosaic Disease is a potential threat in areas with white flies and farmers should use healthy planting material or plant a range of cassava cultivars to mitigate against disease outbreaks.

Insect Pests

- Cassava Green mite and Cassava Mealy Bug are potential threats to cassava. There is need to use tolerant varieties.
- Termites are also a problem especially during dry season.

Harvesting and storage

- Most varieties mature at 12 months after planting however some can be harvested as early as 9 months.
- Harvested tubers are highly perishable and can not be store for more than 2 days in fresh form.

Sweet Potato Production

Time of Planting

- Where there is irrigation and no frost dangers, planting can be done throughout the year.
- However where rainfall is less than 1000mm it should be done early with the onset of the rains..

Varieties

- Improved varieties include brondal and cordner.
- Local varieties include chizou and chigogo.

Soil Requirements

- Well drained sandy to loamy soils.
- Soil pH from 5 to 6.3.
- If pH goes below 5.0 then liming will be necessary.

Climatic Requirements

- Prefers high temperatures of 24 to 29°C.
- Vines are killed by winter frost.
- Requires relatively high light intensity. Requires 750- 1000 mm of rainfall / year

Planting

- Planting is done on mounds of about 20 cm to 30 cm high. Intra row is 20 cm and inter row is 90 cm, but for low rainfall areas wider spacing is recommended.
- It can also be done on ridges or flat land
- Two thirds of the cutting should be in the ground and one third exposed. Plant at a 45-degree angle for increased yields.
- 40 000 cuttings are needed per hectare and cuttings should be 5 to 7 nodes long. Terminal cuttings produce the highest yields.
- The cutting should be at an angle of 45° and should have between half and two thirds in the soil.

Fertilisation

- 60 kg nitrogen per hectare in natural region 1 and natural region 2. Apply in splits, half at planting and the other half a month later.
- Also apply 300 kg per hectare of compound D.
- They respond well to organic manuring.

Propagation

- Usually propagated by vine cuttings, slips or roots.
- Propagation material should be taken from a vigorously growing disease free stock.
- Vine cuttings should be 30-40 cm.

Irrigation

- When rainfall is less than 750 mm during the growing season or if the distribution is poor supplementary irrigation is required.

- Overwatering must be avoided at the later stage of growth since it causes extensive vine growth at the expense of root development.

Weeding

- Weed at 4 to 8 weeks after planting.
- Herbicides like Naptalam, Alachlor and Sencor can be used.

Harvesting

- Lifting can start about 120 days after planting though some cultivars take up to 240 days.
- Roots are suitable for lifting when the cut surface dries to a white colour.
- The plough or potato harvester may be used to harvest but they cause damage so forks or spades are more advantageous.
- After harvesting the roots are left on the land for 2-3 days to suberise.

Yield Potential

- 19t per hectare fresh yield.
- High yielding varieties can reach up to 50t per hectare.

Storage

- They do not store well after harvesting so it is advisable to dig up tubers when they are required.
- After harvesting and curing the tubers can be placed in a basket and covered by grass or banana leaves and placed in a pit lined with grass.

Insect Pests

Sweet potato weevil

- The weevil tunnels tubers resulting in secondary bacterial and fungal infection.
- The adult female bores into the stem or root and deposits an egg in the hole.
- After hatching the larva moves to a storage root which enters and feeds upon the root tissue until it pupates.
- Use healthy material and get rid of infected tubers for control.
- Rotations can also control pests.
- Carbaryl can also be used to control the pest.

Nematodes

- They attack roots and they are controlled by using resistant varieties.

Sweet potato butterfly

- Prevalent in dry season.
- The caterpillar feeds on leaves leaving only skeletons of primary midribs.
- Complete defoliation can occur

Diseases

Sweet Potato Mosaic Virus Disease

- It causes vine clearing chlorosis, puckering, leaf strapping, leaf curl and stunting.
- Control is by burning all affected plants

1. Scurf
2. Charcoal rot
3. Tuber rot

Carrots (*Daucus carota*)

Climatic Requirements

Temperature

- Optimum production temperature is 15 –21 °C.
- At high temperatures, above 25 °C the growth is slower and short thicker roots with pale colour are produced.

Soils

- Plant in deep, rich light soils.
- Insufficiently decomposed manure and stony soils cause forking in carrots.
- The soil pH ranges from 5.5-6.8. Acid soils must be avoided.

Planting

- The crop is sown in situ.
- Can be grown all year round but the best time to plant is May to July.
- Carrots may be drilled in or broadcast but should be thinned after 1 month to leave 3– 6 cm apart. The sowing should be at the rate of 3-8 kg/ha.

Fertilization

- Before sowing apply a basal fertilizer of 100– 200kg / ha Compound D.
- . Manure may be incorporated at a rate of 10-20 tonnes per hectare at sowing.
- Top dressing should be done after 20– 40 days of sowing applying 150 kg of AN.

Irrigation

Supply 35 mm –55 mm every 7-14 days

Cultivar selection

Variety	Days to maturity	Maturity Category
Kuroda	70 - 120	Medium
Chantenay	70 - 120	Medium
Nantes	70 - 120	Medium
Laguna	85 - 95	Early
Star 3006	85 - 95	Early

NB: Buy seed from a recognised seed dealer. Keep the pack together with the paper found inside

Weed Management

- Care should be taken in weeding to avoid damaging roots
- Weeds can be kept under control by mechanical means.

Insect Pest Management

Pest	Symptom	Control
Aphids	Sucking pests Leaves wilt and turn yellow	Dimethoate 40EC at 10ml/10L of water.
Nematodes	Attack the root and cause slow growth Tubers are deformed, forked or stringy	Crop rotation and use of resistant plants and soil disinfection

NB: For details on chemicals, consult your local AEW or chemical representative. For rate of application refer to container

Diseases

Disease	Symptoms	Control
Powdery Mildew	Whitish growth on leaf under surface and later whitish spot appear on both leaf and stem surface.	Application of sulphur in the form of Dithane M45 at 30g/15l water or Benomyl at 30 ml/15 l water
Leaf Blight	Blackening of foliage which subsequently dies	Dithane M45 20g/ 10L Copper oxychloride 85% wp 200g/100L every 7 – 10 days
Bacterial Soft Rot	Reduce the carrots to a soft slimy mass	Growing carrots in well drained soils, Rotation– do not follow carrots after lettuce or cabbage. The roots must be kept well ventilated after lifting

Harvesting

- Done after 3 months, ideally when the roots are more than 2 cm diameter.
- A plough must loose the soil first. Harvest during cooler day times and keep in a cool place or sprinkled with water to maintain the fresh state.
- The tops are cut off and carrots are packaged in transparent film bags to increase shelf life.
- The expected yield is > 25 tonnes per hectare with good management.

Storage

- The crop can be stored for 6 months at about 0°C and relative humidity of 93-98 %..

Cabbage

Climatic Requirements

- Requires daytime temperatures ranging between 16⁰C and 24⁰C.
 - Mature plants can tolerate temperatures of -3⁰C for a very short period.

Soil Requirements

- Can be grown in well drained soils, provided they are adequately fertilised and well supplied with organic matter (manure).
- Slightly acidic to neutral soils are required with a pH range of 6.5 - 7, and with a good water holding capacity.

Land Preparation

The soil should be worked to a fine tilth.

Planting

Highveld - August to April

Lowveld - January to May.

- Certified disease-free seed should be used.
- Retained seed should be heat treated at 50⁰C for 25 minutes to eliminate seed borne diseases. The seed should then be dried and dusted with 2 g Thiram/kg seed.
- Sow seed in seedbeds using a rate of 300-450 g for one hectare.
- The seedbeds are treated with 60 g of compound sand and 3 kg manure per m².
- It takes 7 - 14 days from germination to emergence
- Emergence to transplanting it will take four to eight weeks depending on variety.
- Harden seedlings and transplant when they are 10 - 15 cm tall
- Transplant with the roots intact and irrigate immediately after transplanting to reduce transplanting shock.
- Only healthy and vigorous seedlings should be used and transplanting should take place in cool overcast weather or late in the afternoon.

Spacing

The recommended spacing is shown in the table below and vary depending on the variety of cabbage grown.

Variety	In-row (mm)	Between rows (mm)	Population/ha
Early	300	450	74 000
	450	450	49 300
Mid-season	450	500	44 400
	500	600	33 300
Late	450	750	29 600
	600	750	22 200

Fertilisation

- A basal dressing of 1000 kg/ha compound S is recommended or manure can be used at a rate of 25-50 tonnes/ha.
- Topdressing using ammonium nitrate is done using a rate of 100 kg/ha. This is applied twice at three weekly intervals after transplanting.

Irrigation

Irrigation schedule for cabbage

Assumed planting Out date	First month of planting out (Days)	Remainder of growing period (Days)
Application of 35 mm net per irrigation		
April	12	8
August	8	5
December	10	6
Application of 45 mm net per irrigation		
April	16	10
August	10	6
December	12	8

Cultivar Selection

Variety	Days to maturity	Maturity Category
Golden Cultivar	65 – 90	Early
Cape Spitz	75 – 110	Medium
Copenhagen Market	70 - 110	Medium
Drumhead	120 - 160	Late
Adelita F1 hybrid	71 - 80	Early
Rotan F1 Hybrid	70 - 80	Early
Star 3311 F1 Hybrid	75 - 85	Early
Green Coronet F1 Hybrid	120 - 140	Late
Star 3315 F1 Hybrid	90 - 100	Medium
Klabishi F1 Hybrid	90 - 100	Medium
Marcanta F1 Hybrid	70 - 80	Early

Weed Control

Weed	Chemical	LR/SR (Long/short residual effect)	Stage of application
Annual and certain broad leaf weeds	Trifluralin	Residual for approximately 4 months	Cross-disced into soil before transplanting.
Annual and certain broad leaf weeds	Lasso	Residual for 6 –8 weeks	After first transplanting irrigation but before weeds emerge
Annual and Perennial grasses	Fusilade Super		Apply after weed emergence

NB: For details on chemicals, consult your local AEW or chemical representative. For rate of application refer to container

Insect Pest Management

PEST	SYMPTOMS	CONTROL
Bagrada bug	Leaves wither and young plants may even be killed if the attack is severe	Dichlorvos 5% EC at 200 ml/100 litres water, or Parathion 25 WP at 125g/100 litres water.
Cabbage	Small soft-bodied sucking insects	Dimethoate 40% EC at 75ml/100 litres

Aphids	that feed on the crop leaves and stems	water.
Cutworms	Cut young plant stems at the base.	Bait made up of 100 kg mealie meal plus 625 g endosulfan, 50% WP is applied to the ground before planting or near plants in the late afternoon. Other chemicals that can be used are Mavrik 2 E, Carbaryl 85 WP and Dursban .
Red Spider Mite	It causes silvering and mottling of the leaves	Same as for aphids.
Diamondback Moth	Mine through the leaf and feed around the growing bud of the young plants. They create irregular holes, sometimes leaving the upper surface of the leaf in place (windowing).	Cover sprays at regular intervals of not longer than ten days using endosulfan at a rate of 700 ml (35% EC) in 500 litres water/ha.
Webworm	The larvae feed on the growing points of the young plants causing deformed growth and the formation of many growing points	Same as for Diamondback moth.
Leaf miner	Burrows into leaves causing them to fall or become unmarketable	Same as for aphids

Diseases

<i>Disease</i>	Symptoms	Control
Bacterial Black Rot	Kills the seedling leaves completely after they turn dark in colour. When the plants are larger, the disease causes yellow V-shaped areas at the edge of the leaves, particularly lower leaves near to the soil.	Use of resistant varieties Use of certified disease free seed
Bacterial Soft Rot	Cabbage turns soft and rotten with a bad smell	Plant on ridges to prevent water logging around the plants Prevention of other diseases will reduce the ability of soft rot to penetrate the crop. Avoid harvesting under warm moist conditions Wash and disinfect hands and harvesting knives. Avoid growing cabbages in the same field for at least three seasons

Yellows	Leaves often bend sideways since only one side of the leaves sap tubes is blocked, but they do not survive long and usually go yellow and drop off.	Growing resistant varieties and by practicing crop rotation
Downy mildew	Fluffy fungal growth on the underside of the leaf.	Dithane M45 at 200g/100 litres water every seven to ten days. Dip seedlings at transplanting.
Damping off	Damping off and wire stem of seedlings in the seedbed and bottom rot and head rot in growing cabbage crops or after harvest	Sow seed thinly and drench with Thiram at 10 g/5 litres of water each week.

Harvesting

- Harvesting takes place 60 to 90 days after transplanting depending on variety.
- As soon as the heads are full, firm, well closed and sufficiently developed they should be harvested.
- Harvesting may be for a period of 15 to 20 days at 4-day intervals.

Yield

- Expected yields vary according to variety.
- Open pollinated varieties yield 30 - 35 tonnes/ha and F1 hybrids yield 50 - 75 tonnes/ha.

Onion Production

Climatic Requirements

Temperature

The optimum temperatures are 18—27° C.

- Bulbing is more rapid at warmer temperatures and low winter temperatures induce bolting which results in reduced yield, quality and storage potential.

Soil Requirements

- Requires well drained soils with high levels of organic matter.
- The soils should be fertile and should be ploughed to a depth of 600mm.
- The suitable pH is 5.0 to 6.8

Planting

- The planting time is February - March
- For direct sowing use a seed rate of 5-6kg/ha
- Construct nursery bed 1- 1.5 metres wide, leaving a 50cm path between the beds.
- Apply basal fertiliser of Compound S at a rate of 450 to 550kg/ha and incorporate into the soil. Manure or compost can also be used.
- Top dress with 350g/m² of ammonium nitrate 2-3 weeks after emergence avoid over application as too much Nitrogen may cause excessive foliage and delayed bulbing.
- Mark out rows 10 - 20 cm apart across each bed. Do not broadcast the seed.
- 2.5 -3 kg of seed is sufficient for a hectare and will need a nursery with an area of 300m² when the seed has been sown into the marked out lines, cover with sand or if the sand is unavailable cover lightly with soil then mulch and irrigate
- Transplanting is done after 8—10 weeks when seedlings are pencil thick and are about 15—25cm long.
- Mulch must be removed gradually as seedlings grow.

Approximate irrigation schedule for the nursery

- Apply two light irrigations daily until germination.
- Apply 5mm daily for the first week after germination
- Apply 10mm every two days up to 8 weeks from sowing.

Sets or Bulblets

- This method leads to early maturity has the advantage of harvesting early by 50—55 days but is not commonly used.
- Sowing is done in August—September.
- Bulbs mature in three months and these are lifted and resown in January—February.

Transplanting

- Plough, disc and harrow the field to a depth of 30 cm.
- Broadcast and incorporate lime (preferably a month before transplanting). This is only necessary when pH falls below 5.0 (CaCl₂).
- Broadcast compound S at a rate of 800-1000 kg/ha and incorporate. Top dress with 100-kg/ha ammonium nitrate 4-6 weeks after transplanting.

- Transplant to 5-7.5cm spacing within row and 30 cm between rows.

Irrigation schedule for the field is as follows:

- 20 mm weekly from 8 to 10 weeks
- 40 mm fortnightly from 10 to 14 weeks from sowing
- 40 mm every 7 to 10 days until bulbs mature
- Stop irrigation when 25% of the tops have collapsed

Cultivar selection

Variety	Days to maturity	Yield
Radium	210 - 220	8 – 10 t/ha
Texas Grano	210 - 220	60 t/ha
White Lisbon	180 - 200	10 – 25 t/ha
Red Pinoy	120 - 150	20 - 25 t/ha

NB. Expected yields vary depending on cultivar, planting date and management.

WEED MANAGEMENT

Weed	Chemical	LR/SR (Long/short residual effect)	Stage of application
Annual and perennial grasses	Fusilade super		Apply early post emergence of grass and crop
	Ronstar	3 months	Apply immediately after planting seedlings or sets
Broad leaves and grasses	Goal		Apply to clean land at 10 to 18 days after transplanting

NB: For details on chemicals, consult your local AEW or chemical representative. For rate of application refer to container

Insect Pest Management

PEST	SYMPTOMS	CONTROL
Thrips	Silvery or blanched appearance on leaves, tender centre leaves become curled and deformed, outer leaves turn brown at tips	Thionex 35 EC
Cutworm	Cuts plants at the base	Karate

NB: For details on chemicals, consult your local AEW or chemical representative. For rate of application refer to container

Diseases

Disease	Symptom	Control
Purple Blotch	Small irregular white patches on the leaves	Dithane M45 Ridomil
Downy Mildew	Grey down covering the leaves	Dithane M45. Ridomil Gold

White bulb rot	Black sooty—like mould between the scales	Benlate Quintozene
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NB: For details on chemicals, consult your local AEW or chemical representative. For rate of application refer to container

Harvesting

- Done when at least 50% of the tops have wilted/collapsed.
- A light irrigation is applied before harvesting.
- Sort and grade, removing all thick-necked onions, then store in a well ventilated shed with low temperature and low humidity.
- Inspect weekly and remove all spoiled bulbs.
- Expected yields vary from 20-100 t/ha depending on cultivar, planting date and management.

Tomato Production

Climatic Requirements

Temperature

- Should be grown in frost-free areas and optimum growth temperatures range from 18 – 25 °C.

Soil Requirements

- Optimum pH is 5.0– 5.5 CaCl₂.
- Liming is done when pH is below 5.0.
- Grows best in sandy loam soils

Seed bed

- The seed rate is about 120– 160 g in a nursery seed bed of about 60 m².
- Emergence takes 7 -10 days depending on prevailing soil temperatures.

Seedling trays

- These are mostly made of silicon boards.
- Trays should always be suspended on tables or benches to allow for free water movements and root pruning.
- Seedling trays offer a good stand of crops at germination and transplanting if used correctly.
- At transplanting the seedling is taken with the soil that it germinated from which reduces root damages which causes transplanting shock.

Boxes or asbestos trays

- Care should be taken to allow for free drainage to prevent damping off of seedlings.

Transplanting

- Transplanting id done 6 -8 weeks after emergence.
- Harden seedlings when they have 3-5 true leaves and are pencil thick or approximately 12 cm tall.

Spacing

- Use 300 mm to 500 mm in row and 1.5 – 2 m between rows.

Fertiliser Management

- Apply basal dressing of Compound S 1 000– 1 500 kg/ha (6:17:6), or Tobacco fert (6:15:12) at 700 kg/ha Broadcast half and disc into the soil then apply the other half at planting
- Apply top dressing of Ammonium Nitrate and Potassium Sulphate each at 100 kg/ha, split into 2 or 3 applications.

Cultivar Selection

<i>Cultivar</i>	Growth Habit	Fruit Shape/Quality
Alboran	Determinate	Round, Smooth and pleasant taste
Rodade	Determinate	Good quality with high grading
Roma	Determinate	Long red and almost plum shaped

Floradade	Determinate	Firm fruit
Money maker	Indeterminate	Round red firm fruit
Red Khaki	Determinate	Poor fruit firmness
Rossol	Determinate	Poor fruit firmness
UC82B	Determinate	Firm block fruit
Heinz	Determinate	Medium firmness
Fortune Maker F1	Determinate	Square shaped, thick walled
Adelaide F1	Indeterminate	Round, firm deep red
Thomas F1	Indeterminate	Medium to large size, deep red
Raissa F1	Indeterminate	Glossy fruit with constant size
Star 9030 F1	Indeterminate	Round smooth fruit

Weed Management

Weed	Chemical	LR/SR (Long/short residual effect)	Stage of application
Annual and perennial grasses	Fusilade super		Apply post emergence to young and actively growing weeds
Broad leaves and annual grasses	Sencor 480 SC Trifluralin (Trif)	8 – 12 weeks and longer 5 months and longer	Apply as directed. Spray at least 14 days after transplanting Cross disc into soil before transplanting

Pests

PEST	SYMPTOMS	CONTROL
Cut worm	Cut young plant stem at the base	Carbaryl, Dursban, Pyrinex, Karate
Aphids	Suck plant sap and reduce plant growth.	Dimethoate, Metasystox 25 EC, Malathion 50%
African Bollworm	Feed on leaves, flowers and fruit	Thionex 35 EC, Dede vap, Tameron 600 SL, Carbaryl, Dipterex 95 SP
Red spider mite	Leaves may become spotted, yellow, brown or silvery	Malathion, Dimethoate 40 EC, Mitac, Armitraz 20 EC, Kelthane 18 EC, Dicofol
Leaf miners	Causes white spotting or stippling in leaves	Tameron, Trigard
Whitefly	Suck plant sap and reduce plant growth.	Confidor, Naturell, DDVP

Diseases

Disease	Symptom	Control
Bacterial	Wilting of the foliage, stem splitting and	It is controlled by using healthy

canker	mealy breakdown of internal tissues of the stem with a separation of wood from pith.	seeds, planting on ridges and the use of crop rotation
Bacterial wilt	Sudden wilting of the plant, browning of woody tissues from which bacteria slime oozes after cutting across the main root and lower part of the stem	Use crop rotation and avoid use of areas prone to water logging.
Bacterial spot	Dark brown raised pustules on the fruit, later becoming slightly sunken and scabby.	Healthy seed , crop rotation and Copper oxychloride, Mancozeb, Captan and Metiram
Bacterial Speck	Brown spots 2mm in diameter on leaf edges On fruit black slightly raised superficial spots 3mm in diameter	Use certified disease free seed Copper oxychloride and Mancozeb
Early blight	A dark reddish brown leaf spot with concentric markings appearing first on the lowermost leaves, causing defoliation. Infection of the fruit is usually associated with cracks and other skin injuries	Copper oxychloride and Mancozeb, Ridomil, Maneb, Bravo
Late Blight	Greyish green water soaked lesions on the leaves which rapidly turning black Lesions on the stem are dark brown and large mottled brown areas develop on the fruit.	Copper oxychloride and Mancozeb, Ridomil, Maneb, Bravo, Captan
Tomato mosaic virus	Affected plants show light and dark green mottling. Young leaves may be distorted and will show stunted or elongated growth in condition known as the fern leaf	Use resistant cultivars Control vectors Practice good hygiene Rogue out and destroy infected plants
Tomato spotted wilt virus	Tomato spotted wilt symptoms include overall yellowing, spots on leaves or terminal shoots and general stunting.	
Tomato yellow leaf curl virus		

Physiological disorders

Physiological disorder	Symptom	Control
Blossom end rot	Appears as small 3 3 water soaked area at the blossom end of fruit. This enlarges, becomes sunken and turns black and leathery and sometimes turning the core of the fruit brown.	Grow resistant cultivars such as the processing cultivars. Foliar applications of calcium chloride at transplanting time can be useful.
Puffiness	Fruits appear and angular. The fruit feels lighter than it should be and when cut holes in the flesh are seen.	A sound nutrition regime should be followed.

Sunscald	White or light tan discoloration of the fruit that has been over heated due to sun exposure.	Care should be taken when pruning fruits and harvesting not to overexpose fruits to the sun.
Fruit cracking	In concentric cracking, the fruit normally develops circular, concentric cracks around the stem end of the fruit. Radial cracking, the fruit cracks radiate from the blossom end.	Use cultivars that are tolerant to cracking such as Floradade and Rodade.

Harvesting

- The stage at which harvesting is done will depend on proximity to the market, package available and the variety of tomato being harvested.

There are four distinct stages at which tomatoes can be harvested.

- Pale blossom-end stage—Cream coloured streaks at blossom end of the fruit.
- Pink blossom-end stage—Pink dull red colour at blossom end of the fruit.
- Pink stage—Dull red fruit
- Ripe stage—the fruit is virtually ripe but still firm.

Yields

- Yields of over 100t/ha can be obtained depending on cultural practices and cultivars. However a yield range of 20-60 t/ha is usually achievable.

Storage

- Ripe tomatoes may be stored for 7 to 10 days at 5 to 10 °C and humidity of 80 to 85%. To increase storage life, fruits should be harvested at the mature green stage.

Okra

(Abelmoschus esculentus)

Varieties

There is only one improved variety that is available on the local market and this is the American variety Clemson Spineless.

Uses

- The cooked pods are used as relish and are consumed with the staple sadza.
- The seeds have a high oil content that can be extracted for household and industrial uses.

Climate

- It is best grown in hot areas or during summer either as a rain-fed crop or under irrigation.

Soils

- It can be produced on well drained sandy loam soils with an optimum pH range of 6-6.8 (CaCl₂).

Fertilizers

Basal fertiliser:

- Apply 450-750 kg/ha Compound C or Compound D per planting station. Cover the fertiliser with a bit of soil before placing the seed and covering it..

Top dressing

- Apply 290 kg/ha ammonium nitrate split 2-3 times starting 3 weeks after seed emergence and at three week intervals thereafter.

Spacing

- Inter row spacing of 60-90 cm and in row spacing of 20-30 cm depending on the size of the variety being grown.

Time of Planting

- In the highveld plant from August to December under irrigation. December to April during the rainy season.
- In the lowveld planting all year round is possible where irrigation is available.

Crop Establishment

- 8-10 kg of seed will be enough to plant a hectare.
- Direct seeding is the most common method.
- Raising seedlings in the nursery as transplants in seedling trays is another possible method.
- Pre-soaking seeds in water a day before planting increases the germination percentage.

Harvesting

- Harvest the young pods 5 to 10 days after flowering while the pods are still tender and not fibrous.
- Harvesting can continue once per week for more than two months.
- Yields of up to 2-3 t/ha are obtainable.

Diseases

Powdery mildew

- This disease is common in okra especially when the plants are fully mature.

- The symptoms are white powder on the leaves and stems.
- It is controlled by the fungicides Dithane M45 at a rate of 20 g/10 litres of water.

Cercospora leaf spot

- This is observed as brown spots on the leaves with the middle part of the spot being white.
- It is controlled by spraying with Dithane M45 at a rate of 20g/10 litres of water.

Pests

Aphids

- The symptoms are curled leaves and growing tips resulting in retarded growth.
- They are controlled using Dimethoate 40 EC at a rate of 10 ml/10 litres of water, or Malathion 25 WP at a rate of 20 g/10 litres of water.

Root-Knot Nematodes

- They infect the roots of the plant affecting movement of water and minerals within the plant.
- Symptoms are stunted growth and swollen galls on the roots.
- Control is best by observing crop rotations at 4 year intervals excluding other nematode sensitive crops

Garlic

- Garlic is used as condiment for flavouring and it also has medicinal properties. It can be dehydrated and crushed to powder, for use in different dishes.

Climate

- Garlic is less able to stand high temperatures.
- The crop is frost hardy.
- Optimum growth is achieved at 12-16 °C and the best planting time in Zimbabwe is April to May.
- Bulbing occurs during longer days and higher temperatures and subsequent exposure to lower temperature.

Soils

- Requires well drained soils with good tilth and which are rich in organic matter..
- Soil pH range is 5.5-6.0 (CaCl₂) for best results.

Propagation

- Garlic is propagated by segments of bulb called cloves.
- The seed rate is 900-1100 kg /ha.
- Use biggest cloves to obtain vigorous high yielding plants.

Planting

- Soils should be worked to a fine tilth.
- The cloves should be separated carefully to avoid double cloves which give twin plants and misshaped bulbs. Plant with the tip of clove just above ground level.

Spacing

- Rows spacing is 20 cm. Place the cloves at 8-10 cm apart in the row.

Fertilisation

- Apply compound C at a rate of 350-500 kg /ha and top dress with 200-300 kg /ha AN per month after planting.
- Garlic also responds well to Organic Manure.

Irrigation

- Never allow garlic to run short of moisture.
- At each irrigation water to field capacity .Water less frequently but increase the rate during bulb enlargement and cease watering 1 month before harvest.

Diseases

- Garlic is not very susceptible to diseases but some of the diseases are listed below.

Downy mildew

- Common when weather is wet with high humidity. Symptoms include a violet – greyish mould on the leaves.
- Can be controlled using Radomil at the rate of 25 g /10 L of water.

Purple blotch

- Causes drying of leaves with sunken spots.
- Leaves become purple with yellow halo.
- Can be controlled using Dithane M45 @ 20g/ 10 litres of water or Bravo 10ml/ 10l of water.

Neck rot and Black mould

- These are destructive storage diseases which result in bulbs turning black.
- Can be controlled by storing under low temperatures and well ventilated rooms.
- Eliminate any damaged diseased bulbs before storage.

Pests

Thrips

- These cause silvery blotches on leaves and are usually found inside the leaf sheath at the apex.
- Scouting is very important because usually when symptoms appear on leaves the damage would have occurred.
- Control using Malathion 20g/10 litres of water.

Nematodes (*Dictylenchus dipsaci*)

- May infect the bulb and stem of plant the basal portion of plant becomes swollen, spongy and splits followed by decay.
- Stunted growth and twisting also occur.
- Always check source of planting material to avoid transferring nematodes and diseases.

Harvesting

- Crop matures 4-6 months after planting. Harvesting should be done in August to October when conditions are dry
- The bulbs must be lifted and left to cure on the ground for a week.
- Expected yield is 8-12 tonnes /ha with good management. .

Post Harvest

- At higher temperatures of (26 –32 °C) garlic can be stored for 1 month.
- . Intermediate temperatures (4.4 –18 °C) favours rapid sprouting and high relative humidity cause moulding.
- At 0 °C and 65 % relative humidity, garlic stores for 28-36 weeks.

Strawberry Production

Nursery Establishment

Site

- Selected site should be far from other strawberry fields to reduce the chances of infection with nematodes and viruses
- It should be free from frost.

Soil

Deep well-drained soil is desirable.

Fertilisation

Fertiliser recommendations for runner and field production

- 300 kg/ha Tobaccofert (6:18:15) should be broadcast and disced into the soil before planting.
- 3 - 4 weeks after planting top-dress with 200 kg/ha ZFC Coffeefert (14:5:20) or 150 kg/ha ZFC Coffee Blend (16:5:22).
- Three topdressings of 100 kg/ha Ammonium Nitrate are sufficient.

Spacing

- Plants should be established on raised beds (1m - 1.2m wide) or ridges spaced 0.90 m apart.
- A spacing of 1m x 1m is best for runner production. Spacing for fruit production is 30 cm x 45 cm or 30 cm x 30 cm.

Planting

- Trim roots to about 10 cm. remove all leaves except one or two (this minimises transpiration).

Spread the roots before covering in the soil. The plant is then set with the crown just above the ground level. It is best to plant in moist soil and irrigate immediately.

Irrigation

- Irrigation should be to field capacity at planting and during the first 4 weeks, watering 3 times a week.
- Water should be increased during hot days and reduced at cooler times.

Pests

- Aphids and other pests should be controlled by spraying every two weeks with Dimethoate - Thionex, Thiodan, Carbaryl and Malathion can also be used.
- Bravo or Benomyl alternated with Dithane M45 applied once or twice a week will control most fungal pathogens.

Harvesting

- Runners should be lifted in February/March.
- When lifting daughter plants, the mother plants (branch crowns) should always be discarded. An average of 35-40 runner plants per mother plant can be expected.

N.B. Runners should not be allowed to set flowers as this retards the vigour of the newly-set plants and slows runner productions.

Field Planting

Soil

- Deep well drained, light soils with plenty of compost (20-30 t/ha).
- pH should be in the range of 5.5 - 6.5 (CaCl₂ scale).

Field preparation

- Raised beds (1m - 1.2m) 0.90m apart or ridges are recommended.
- The strawberry crop should not follow after a crop susceptible to verticillium wilt (such as tomato and potato).

Fertilisation

- Pre planting: 500 - 750 SSP/ha and 200 kg K₂SO₄/ha broadcasted and mixed to a depth of 30 cm.
- After establishment (at 4 weeks): 75 - 100 kg AN/ha as topdressing, then 75 - 100 kg AN/ha and 100 kg K₂SO₄/ha from commencement of active growth at monthly intervals.

Planting time

February to April is the best time to plant.

Spacing

- Spacing should be 30 cm x 45 cm on raised beds. Closer spacing may be used if planting is late to compensate for the small size of the resulting plants.
- Plant population of 45000 plants/ha.

Mulching

- UV stabilised black or clear plastic or rye grass can be used as mulch.
- Strawberries can also be produced in tunnels.

Irrigation

- Frequent light irrigations are recommended as strawberries are shallow rooted. .

Frost

- A frost free site should be selected.
- Straw mulch should be used where/when there is danger of frost e.g. during winter.

Harvesting

Fruit should be harvested at red-ripe stage (130 - 135 days after planting for the early planted crop). The harvesting may last for 2 - 3 or more weeks. For shipping, berries should be harvested slightly earlier. The fruit will colour fully after harvesting..

Post - harvesting handling

- Harvesting should be done with minimal damage as the crop is very perishable.
- The fruit should be picked with the stalk attached, placed in shallow punnets and cooled to remove field heat.

Cultivars

Rolinda

- High yielding with rather soft, small berries. It has some resistance to mites.

Rovelle:

- Very firm, among the hardest. Has a very good flavour.

Selekta:

- It has firm, large conical berries. Selektta is very popular in taste and appearance. The flavour is good in winter but rather tart in summer.

Tioga:

- An early cropper, usually earlier than Selektta. Has large berries that are firm throughout the season. The flavour is superior to Parfaite and can be better than Selektta. It has uniform ripening and is more resistant to mites. Has been grown under tunnels.

Tiobelle:

- Has firm, conically shaped and dark coloured fruit very floribundant.

Rolissa:

- Fairly high yielding with small berries. The flavour is good.

Rorine :

- Has medium sized berries with a flavour that can be better than Rolissa.
- A good year yielder.

N.B. Flavour in strawberries depends on the cultivar but might be influenced by other factors such as locality and cultural practices, in particular fertilisation.

Pests

- Nematodes are the most important.
- Aphids and mites might also cause problems. Morestan or some other acaricide can be used against mites. Full cover sprays of Dimethoate at a rate of 75 ml/100l water will control mites
- White grubs - larvae of several beetles - feed primarily on grass roots but can cause severe damage to strawberries. Thiodan (drench) can be used as a control. It will also control cutworms.

Diseases

- Verticillium wilt, which is soil-borne, can be controlled avoiding planting after a solanaceous crop..

Pepper Production

Propagation

Sowing

- Seed is sown in spring after the danger of frost has passed.
- Seed should be dressed with some fungicidal dressing such as thirum and soil should be treated by solarisation.
- Spacing of 75 X 45 cm or 90 X 45 cm with a seed rate of about 150-200 grams per hectare is used.
- Seedlings are transplanted after four to six weeks when approximated to be about 15 cm tall.
- Any fruit that may have developed at transplanting should be removed because it causes dwarfing of the plant and hence reduces yield.

Soil Requirements

- Sands and sandy loams are preferred.
- Heavy soils should always be avoided because of their poor drainage

. Ideal pH lies between 5.5 and 7.0 CaCl₂ scale.

Fertiliser Applications

- Adequate organic manure is necessary and recommended at the rate of 25– 35 mm tonnes of compost or manure per hectare.

Harvesting And Storage

- Harvesting commences two or three months after planting and continues with regular pickings at intervals of one to weeks for a period of three months.
- Ripe chillies can be stored at 4.5 –7 °C and will keep for three or four weeks at these temperatures.

Tsungu Production

Introduction

Tsungu *Brassica juncea* belongs to the *Brassicaceae* family, so it shares the same diseases and pests with cabbage, Rape, Covo and Rugare.

Uses

- The leaves are cooked as a vegetable. The vegetable is commonly mixed with onion, tomato and cooking oil.
- The most popular is when it is prepared in peanut butter. Tsungu can also be dried green or after a few minutes of par-boiling

Production Requirements

Soil

- Does better where soils are rich in organic matter, leaf size and quality improves where organic manure is added.
- Soil pH should range between 5- 6 (CaCl₂). Avoid waterlogged soils.

Time of Production

- It is common or was common for rural women farmers to grow Tsungu during the rains December-April and on anthills.
- The highest yield are obtained when planting is done in April to August, as the cold winter temperatures delay flowering and induce the production of bigger leaves.

Fertilizers and Manure

The following fertiliser rates are recommended.

Basal fertiliser

1. 50 t/ha manure no basal fertiliser except top dressing
2. 30 t/ha manure and 150 kg/ha Compound D
3. 450 kg/ha Compound D

Top dressing

- Apply 290 kg/ha ammonium nitrate split three times.
- First application 3 weeks after emergence and the rest is applied in three splits at three week intervals.

Spacing

- Rows can be spaced at 30-50 cm. inside the row plants should be spaced at 30 cm.

Crop establishment

- Apply the manure and basal fertiliser and mix it in the soil.
 - Mark the rows and planting stations and plant 3 to 4 seeds per station. Thinning to one plant per station is done when the seedlings are 2-3 weeks old.
 - Thin to one plant per station and apply the first top dressing after.
- Irrigate before and after thinning to allow soil around the seedlings to settle. .

Harvesting

- Harvest leaves after about 6 weeks of growth. Do not remove all the big leaves, leave one for subsequent growth.
- Harvest once per week and the number of leaves per harvest per plant will depend on the plant growth conditions..

Diseases

- Fungal diseases may appear if the crop is produced during the rainy season. Spray with a fungicide at least once a week if conditions remain humid.

Pests

- Aphids have been observed on Tsunga and are controlled using Malathion or Dimethoate.
- Bagrada bugs (*vanaRudo*) suck the sap from the leaves and leave dry spots on the leaf making them unsightly and unmarketable. Bagrada bugs are controlled using Carbaryl, Dichlorovos (Dedevap) and Parathion. Other organic methods of control are available.

Potato Production

(*Solanum Tuberosum*)

Soils

- Best soils are medium textured loamy soils with good organic matter content and a pH of between 5.0 and 5.5 (CaCl₂).

Land Preparation

- The land should be ploughed to a fine tilth which is necessary for good tuber development and a soil depth of at least 600 mm is preferable.

Seed

Certified seed should always be used in the production of potatoes..

- **Grade 'AA'**

Varietal purity: 99.5%

Health: Not more than 0.25% leaf roll or severe mosaic viruses.
Not more than 2% visible mild mosaic
No bacterial wilt at any growth stage

- **Grade 'A'**

Varietal purity: 99.5%

Health: Not more than 1% leaf roll or severe mosaic viruses
Not more than 2% visible mild mosaic

- **Grade 'XX'**

As for Grade A, but tubers have been subjected to a limited amount of mechanical damage.

- Grade AA is available for a limited period (June-July) in any one year, while Grade A is available throughout the year.
- Newly sprouted seed produce the most vigorous plants and highest yield. Newly sprouted seed is used when the sprouts are between 5 and 15 mm long.
- Tubers which are firm, disease free, reasonably free of damage and which have strong sprouts should be selected. Seed is sorted according to size and tubers smaller than 25 mm are discarded.

Sprouting

- On a commercial scale, seed potatoes are usually unsprouted when obtained. These should preferably be sprouted under daylight conditions with protection only from the strongest sun.

Force sprouting

- Heat: A constant temperature of 30-35 °C will initiate sprouting. Merely covering with a tarpaulin in moderate sunshine will help.
- Acetylene:
 - a) The tubers may be stacked in an air-tight room at 21-27 °C containing 0.1 per cent acetylene gas. 30 g calcium carbide will generate sufficient gas for 2 m³.
 - (b) Immersion in acetylene solution for 4-6 hours. For 45 litres of solution 230g calcium carbide is added slowly.
 - Sprouting can be retarded by storing the seed at low temperatures, for one year at 3 °C, or by the application of a sprout inhibitor..

Varieties

Montclare

- A very high yielding variety, producing medium quality tubers, which tend to be large and of poor shape with deep eyes.
- It is late maturing variety and is an uneven sprouted.
- It's resistant to Late Blight but is susceptible to virus diseases.

BPI

- A medium-early variety, taking 3-4 months in the ground.
- White flesh, hard skin, good oval shape and very high yielding.
- It is fairly resistant to Late blight.
- An even sprouter.

Pimpernel

- Late maturing variety, medium yield, and red skinned, yellow fleshed tubers for 'chip' trade.
- Keeps well, has good field resistance to Late blight and is fairly tolerant of virus diseases.

Inyanga Amethyst

- Late maturing, white purple flowers.
- White fleshed flat oval, shallow eyed, white skin with slight russet and quick sprouting.
- Consistently high yielder, both in summer and winter. Good resistance to Late blight.
- New varieties that are available on the market are Jasper and Garnet.

Fertilisation

Fertiliser Nutrient Status Of The Soil Nutrient

	Good	Medium	Poor
	Kg per Hectare Of Fertiliser Nutrient Required		
Nitrogen	Up to 70	70—110	110—160
Phosphate	Up to 325	350—400	400—450
Potash	Up to 70	70—110	100—135

- All phosphate and potash requirements should be applied at/before planting, by banding to the side of the seed.
- To reduce fertiliser burn a single line may be drawn along the bottom of the furrow to mix it with the soil, or the fertiliser covered with a thin layer of soil before planting the seed.
- Another method of application is to broadcast the fertiliser after ridging, set the seed in the furrow, then split the ridge back over the seed
- . When the tubers are in direct contact with the fertiliser, a good initial irrigation will reduce the chances of burn occurring.
- Compound 'S' (7:21:7) is recommended in cases where it can be obtained.. The rate of application of Compound S ranges from 1300-2100 kg/ha. Part of the nitrogen requirement is supplied at planting in the Compound S and the balance, 100-150 kg/ha ammonium nitrate, is supplied as a top dressing 1-3 weeks after the crop has emerged. The top dressing should be applied between rows or per plant before the final earthing up.

Planting

- Tubers are planted 70-100 mm deep under irrigation.
- Dryland planting may be up to 150 mm deep.
- Interrow spacing is 900 mm and the inrow spacing is 300 mm. .
- Large seed tends to produce more stems and a higher proportion of smaller tubers, small seed.
- Seed producers will use a spacing of 600-1200 mm between rows and from 150-160 mm in the row.
- Seed is supplied in 30 kg pockets containing sizes from 25 to 56 mm and an average of 400 tubers per pocket

Time of Planting

- Potatoes can be grown all year round in the middleveld and highveld. However because of considerations of frost, wet months and utilisation of irrigation equipment, three main planting times are recognised.

Summer crop

- Normally planted in November to mature towards the end of the rainy season.
- Earlier planting is possible and can lead to very high yields but lifting can be difficult.
- Use late blight resistant varieties since complete chemical control during rains is extremely difficult.

First Winter Crop

- Planted from February to April to mature before frost according to area, but later in the lowveld to take advantage of cooler weather.
- Varieties resistant to Late blight should be grown.
- Supplementary irrigation is essential.

Second Winter Crop

- Planted in late July to early August after the risk of frost has passed.
- Irrigation is required and when flood irrigation is used Late blight is not a problem.
- With the use of overhead irrigation the risk of late blight..

Method of Planting

- A uniform tilth is required and where flood irrigation is used ridging is essential.
- Where overhead irrigation is used planting is done on flat land and ridging is done later.
- Hand planting is done behind a tractor-drawn ridger, which opens the furrows.
- The tubers are placed in the open furrow and are closed by the soil thrown during the following pass.
- Furrows are spaced 90-120 cm and tubers are placed 30-60 cm.

Irrigation

- Potatoes are shallow rooted with a maximum root depth of 600 mm.
- Irrigation to field capacity is done at planting and no further irrigation is done during emergence.
- When the first flower buds appear the crop should be watered regularly until maturity.
- Excessive watering should be avoided since this leads to undue leaching of nutrients and reduces the keeping quality of potatoes.

An irrigation guide is given in the table below:

Soil Type Hot Months Cold Months Irrigation required

Light soils	3-4 days	5-7 days	25-30 mm
Heavy soils	4-5 days	8-9 days	30-35 mm

Weed Control

- Excessive cultivation should be avoided because potatoes are shallow rooted.
- Earthing up by ridging is necessary to protect the tubers from greening, tuber-moth and Late blight and should be planned so as to be an integral part of weed control
- Re-ridging should be completed by the time the plant is 25 cm high.
- The ridges should be made as low as is consistent with good coverage for the tubers and for efficient flood irrigation.
- High steep ridges are subject to greater erosion and more rapid drying due to the greater surface area exposed to the sun.
- Wide flat-topped ridges are satisfactory for making adequate soil available for tuber development and tuber protection.
- Herbicides that can be used are Topogard, Dual, Sencor, MCPA and 2-4D.

Harvesting

- If done early or in the production of seed potato the haulms are destroyed prematurely by hand chopping, use of mechanical haulm pulverisers or rotor beaters or by the use of chemicals.
- Normally harvesting is done when 95% of the leaves have died off.
- When chemical haulm destruction has occurred lifting should be completed inside 10 days to avoid attack by Black scurf (*Rhizoctonia*)
- Harvesting begins when the potato skin has hardened sufficiently to reduce physical damage during lifting.
- The highest yields are obtained when the tubers are harvested 12-15 days after 95% of the leaves have died off under conditions of overcast cool weather.
- In hot dry conditions the tubers should be moved to a sheltered place immediately after harvesting to avoid a reduction in the keeping quality. Only very muddy potatoes should be washed.

Yields

Yield of up to 40t/ha can be obtained but on average the summer crop produces a yield of 17-20 t/ha and the winter crop 24-27 t/ha.

Storage

- At temperatures between 3 °C and 5 °C, potatoes will only start sprouting after 8-12 months.
- Clean pest free tubers should be dressed with 1% malathion and stored in a clean room that has been treated with a suitable insecticide.
- Ware potatoes must be stored in a cold dark place to prevent greening and reduce sprouting.
- Seed tubers are best stored in wooden trays called chitin trays, which have protruding planks on all four corners to facilitate ventilation when the trays are stacked on top of each other.

Pests of Potatoes

Nematodes

Three main types of nematodes occur in Zimbabwe.

- **Root-knot nematodes** (*Meloidogyne spp*) give rise to characteristic watery blisters on the tubers at lifting time. These subsequently collapse and present a rough surface of crinkly scar tissue. This type is most common and economically dangerous.
- **Root-lesion nematodes** (*Pratylenchus spp*) are characterised by lesions on tubers which are visible as slightly raised, light to dark brown-purple areas with a groove-like depressed border. Symptoms may develop during storage.
- **Burrowing nematodes** (*Radopholus*) cause minute intensely black sunken spots easily visible on freshly lifted tubers. This nematode is as yet of little economic significance.
- Control of nematodes is by rotation with nematode resistant grass leys of Ermelo Love, Katambora Rhodes and Sabi Panicum grasses.
- Soil fumigation with EDB can also be done three or four weeks before planting. Due to the ban on EDB alternatives can be used e.g. Nema-cur

Insect Pests

1. Potato tuber moth (*Phthorimea operculella*)

The larvae of this pest cause leaf damage by tunnelling between the upper and lower leaf surface thus hindering photosynthesis, they also tunnel the stems and the tubers.

Control

- Can be controlled using the parasitic wasp *Copidosoma as biological control*.
- Clean fields by removing all tubers after harvesting and by weeding out alternative hosts e.g *Nicandra* (Apple of Peru)
- Ridge up tubers to bury them with about 250 mm soil. Do not ridge just before spraying since covered leaves will receive no insecticide.
- Chemical control using chemicals such as Monocrotophos or Carbofuran.

2. Aphids

- Aphids transmit several virus diseases such as Leaf roll, Necrotic Virus Y and Virus Y.
- They cause wilting, premature senescence and a consequent decline in yield.
- Chemical control can be done using Dimethoate.

3. Cutworms

- Cutworms are the larvae of certain moths that chew through the stems at surface level.
- They are plump, dark, greasy grey caterpillars 25-38 mm long that feed at night

Control:

- Apply a band of insecticide along the rows as a spray or bait.
- Chemicals registered for use in potatoes are Monocrotophos, Deltamethrin, Chlopyrifos and Endosulfan.

4. Potato leaf hopper (*Empoasca fascialis*)

- These are small wedge-shaped insects that feed on the underside of the leaves.
- They rarely cause economic damage and are controlled by Malathion.

5. White grub

- These are soft bodied, white larva with a brown head that feed on the tubers making shallow holes.
- They are controlled by chlorpyrifos at planting.

6. False wireworms (*Trachynotus and Psammodes spp*)

- Tough skinned cylindrical, yellow-brown larvae which eat into the plant stem just below soil level. Control is by Chlorpyrifos.

Physiological disorders

- Black heart Black centre of tuber caused by storage at high temperatures
- Hollow heart Irregular cavities caused by rapid or irregular growth due to irregular irrigation
- Internal browning Occurs on infertile soils which are acid and phosphate deficient

Diseases

1. Late blight (*Phytophthora infestans*)

- It appears as small brown lesions with a pale green border which rapidly coalesce to form black water-soaked areas.
- Under severe conditions all the foliage is destroyed within 5 days of the onset. On the tubers it is seen as a rosy red necrosis of marginal tissue.
- Fungicidal sprays are important on susceptible varieties and may be necessary on tolerant/resistant varieties at peak period, particularly the months of February or March.

2. Early blight (*Alternaria solani*)

- It is seen as target spots, roughly circular, dark brown with concentric markings.
- Most fungicides that control Late blight also control Early blight.

3. Bacterial wilt (*Pseudomonas solanacearum*)

- Symptoms are wilting of foliage, brown discoloration of vascular tissue, and dirty white bacterial ooze which exudes from cuts made across a stem or tuber.
- Control is by using certified seed and cultivation of the crop on disease free land.

Virus diseases

- Leaf roll (*Solanum virus 14*)
- Leaf drop streak (Potato Virus Y)
- Mosaic (Potato Virus X)

Control is by the production of healthy seed in aphid free areas and by limiting spread by aphid control in commercial ware crops.

Green Beans

(Phaseolus Vulgaris)

Beans are classified into two distinct groups:

- Bush or dwarf beans
- Runner or pole beans

Climate and Soils

A relative humidity of not less than 50 percent is required for good setting, although dry, cool conditions are required for harvesting.

- Best yields are obtained on sandy clay loams. The optimum soil temperature range is between 25 and 30°C as this promotes good seed germination.
- Soils which tend to become waterlogged should be avoided as water logging causes flower and pod drop.
- Optimum soil pH is 5.0-5.5 (CaCl₂). Liming where soil pH is below 5.0 is advisable.
- The recommended planting times are as shown below.

Below 750m altitude-sow March, April and May

750m-1200m altitude-sow early September to March

Above 1200m altitude-sow mid/end September to early November and end of February.

Fertiliser Requirements

- The general recommendations for fertiliser application are a basal dressing of 600 kg/ha Compound D and a light top dressing if required of ammonium nitrate at 100 kg/ha.
- The fertiliser must be banded at least 75 mm to the side and 75 mm below the seed rather than broadcasting the fertiliser.
- Boronated fertilisers should be avoided as beans are susceptible to high levels of boron.

Planting

- Seed should be sown at a rate of 80—100 kg/ha, and the seed should be treated with thiram and dieldrin to protect against attack by soil-borne fungi and the stem maggot. Bush beans are planted in situ at a spacing of 50 mm x 450 mm. Double rows 200 mm apart and 700-750 mm apart in the row is more convenient for mechanisation.
- Runner beans are planted 100-150 mm apart, in rows 900mm apart. Planting depth should not exceed 25 mm.
- Beans should be planted in a soil that has been ploughed to a depth of 200-300 mm, and before seeding; the soil should be brought to a reasonable tilth and irrigated.

Weed Management

- Weed control should begin shortly after germination of the seeds.
 - Cultivation must be shallow since most of the roots are in the top 200 mm of the soil.
 - A number of herbicides are available for chemical weed control., examples of some are listed below.
1. Linuron (Afalon), a pre-emergence herbicide applied at a rate of 1.5-2.5kg/ha.

2. Metalochlor (Dual) is another pre-emergence herbicide that is applied at a rate of 1.75– 2.0 litres for grass control. In areas where nutgrass is a problem, the rate is adjusted to 2.0-2.5 litres/ha

Irrigation

- Most of the roots of a bean plant are concentrated in the top 200 mm of the soil, therefore light irrigations are recommended, 35-40 mm (net) on fine textured or clay soils and 25-30 mm on light sands or coarse textured soils.

A guide to irrigation requirements for different altitudes is given below.

1. Above 1000m planted in early to mid September

	<u>Emergence to flowering</u>	<u>Flowering to final harvest</u>
Fine textured Soils	40 mm every 9 days	40 mm every 5 days
Light sands	30 mm every 7 days	30 mm every 4 days
<i>2. Above 1000m planted in late February or early March or below 750 m planted in April</i>		
Fine textured Soils	40 mm every 10 days	40 mm every 8 days
Light sands	30 mm every 8 days	30 m every 6 days

Harvesting

- The first harvest occurs about 14 days after flowering and lasts from three to four weeks
- The crop is harvested by hand when the pods are nearly full size, straight and easily snapped, and the seeds small with a jelly substance surrounding them.
- Beans are ready for the first harvest about 50 days after planting and this continues for 21 to 30 days. Beans must not be harvested during the hottest time of the day, and after rain or irrigation, should be allowed to dry before picking.
- Green Beans usually give yields of 8-10 tonnes/ha

Diseases

1. Rust (*Unronyces appendiculus*)

- Characterised by brown pustules on lower leaves with yellow halo of variable size.
- It is controlled by Mancozeb 80% at a rate of 300g/100 litres of water or Maneb 80% at a rate of 200g/100 litres of water.

2. Anthracnose (*Colletotrichum lindemuthianum*)

- It is characterised by circular sunken brown pits on the pods containing pink spores.
- It is controlled by Mancozeb 80% at a rate of 300g/100 litres of water, Maneb 80% at a rate of 200g/100 litres of water, Thiram 80% at a rate of 200g/100 litres of water Zineb 80% at a rate of 200g/100 litres of water.

3. Bacterial blight (*Pseudomonas midicagiu*)

- It is characterised by small spots with yellow green halos on the foliage, pods and seeds.
- It is controlled using Copper oxychloride at a rate of 400g/100 litres of water.

- Other diseases that can attack beans are scab, pre-emergent damping off and bacterial pustules.

Pests

1. Aphids (*Aphis fabae*)

- Aphids are sap sucking insects that transmit viruses.
- They are controlled using Dimethoate or Malathion 50% or Endosulfan 35%.

2. Bean stem maggot

- This is a small cream maggot that burrows through the stem forming swellings.
- It causes yellowing of the foliage and plant wilt.
- It is controlled using Dieldrin.

3. Heliothus bollworm (*Heliothus armigera*)

- The heliothus bollworm hollows out the plant buds. It is controlled using Endosulfan.

4. Loopers

- These are green caterpillars that eat the leaves and the pods.
- They are controlled using Carbaryl 85%.

5. Red spider mite

- The Red spider mite makes fine webbing on the under surface of the leaf leading to the leaves turning to a silvery colour and mottling of the leaves.
- It is controlled using Malathion 25%.

6. CMR Beetles

- These are large clumsy black beetles with yellow and red markings.
- They are controlled using Malathion 50%.

Granadilla Production

(Passiflora Edulis),

Uses

- It is a popular constituent of cool drinks, cakes, icing and ice creams..

The plant

- Most of the cultivated Passion fruit are woody, perennial climbers.
- The main stem is green in colour while the leader of the yellow granadilla, *P. edulis* forma *flavicarpa*, is maroon to purple in colour.
- The lobed leaves are borne alternatively on the main stem and laterals. In the axil of each leaf, tendrils, which assist the climbing plant and flowers, are borne. . are

The Flowers.

- The flowers are 50 mm in diameter and striking in form and are borne singly in the axils of the leaves along the new shoots.
- Flowers on the younger part of the shoots open later, so that a crop from one flush of shoot growth and fruit setting is harvested during a period of two to three months.

The Fruit.

- The fruit is oval in shape, 50 to 65 mm in diameter and dark purple colour (externally) when ripe.
- It has a hard shell of about 3 mm thick and the internal lemon coloured flesh contains some 150 blackish seeds, each seed being embedded in an individual juice sac
- A selection of this granadilla with a slightly larger fruit is often found in local plantings but this fruit is usually poorly filled and hence of poor quality.
- The yellow granadilla fruit differs from the purple type in that it has a yellow rind when ripe, more aromatic and more acid pulp, brown seeds (larger than *P edulis*) and the fruit is generally larger.
- Pollination can be accomplished by installing a number of beehives in the plantation.

Climatic Requirements

- It is a tropical plant which prefers a moderate temperature throughout the year but is susceptible to frost.
- Mature vines are resistant to a few degrees of ground frost, but the young seedlings are rather tender.
- The yellow granadilla, however, is not frost tolerant.
- In low lying areas like Chiredzi, Middle Sabi, the economic life span of the granadilla is about 3 – 4 years.
- In the higher lying escarpment areas like the Eastern highlands, the plants may produce a reasonable crop for about eight years, depending on management.

The soil

- Prefers well drained medium textured soils.

Planting

- Planting is done as from September to December in cooler areas.
- Obtain seedlings from a reputable nursery.

- Transplant the seedlings when they have attained a height of 60 cm.

Systems in Production

- There are two systems in the production of Passion fruit:.

High density/ intensive system

- Rows are spaced at 4m apart and in row spacing of 10 cm to give a plant population of 25 000 plants per hectare.
- Each vine is trained to the top wire and horizontally, on the direction of the prevailing wind until it reaches the opposite row.
- Vines must be wound loosely around wires to prevent damaging the plants. All suckers should be removed

Low density /Extensive system

- Rows are planted at 1m and 2.5m apart alternately to facilitate tractor movement. Plants are planted in pairs, 20 cm apart with 2m separating each pair. A plant population of 5 714 plants per hectare is achieved.
- Correct trellising is essential to allow light to enter so as to improve fruit colour, reduce insect pests and disease incidence.
- One plant is trained to the low horizontal wire and along it. Laterals are allowed to grow and hang down. Remove all suckers from these laterals on a regular basis.

Fertilization

High density/ intensive system

- Before flowering, apply 150 Kg/ha/ month of compound J and ammonium nitrate 50 Kg/ha/month.

After flowering, apply:

- 100- 150 Kg/ha/month Ammonium Nitrate (AN)
- 100 Kg/ha/month Muriate Of Potash (MOP)
- After cutting back apply 200 kg/ha compound J.

Low density /Extensive system

- Before flowering, apply 75 Kg/ha/ month compound J and ammonium nitrate 30 Kg/ha/month.

After flowering, apply:

- 75-100 Kg/ha/month AN
- 75 Kg/ha/month Muriate Of Potash
- After cutting back apply 150 kg/ha compound J.

Pruning

High density/ intensive system

- Flowers and fruits develop on current season growth; hence pruning is advised to rejuvenate growth, increase air circulation and light penetration.
- Pruning should be carried out in dry weather to reduce diseases.
- Severe pruning from year one is advised.
- Remove all suckers as they come out. After harvest cut back to 30 cm above the ground 12 – 16 months after transplanting.

Low density /Extensive system

- Vines are cut back after harvesting all the fruits.
- Spray to prevent possible *phytophthora* infection.
- Cut back main leaders to about 30 cm below their respective wires.
- Protect against *Anthraco*se die back by painting with a strong fungicide on the cut wounds.

Irrigation.

- As from August to the end of February, apply light but frequent irrigation of 25-35 mm after every ten days.
- No water should be applied during the rains or when the soil has enough moisture. Overhead irrigation should be avoided since it may promote the development of foliage diseases.

Weeds

- Hand weeding is the most appropriate.
- Appropriate herbicides may also be used depending on the type of weeds in the orchard.

Harvesting

- Fruits are harvested when they are 90-95% coloured depending on the distance from the market.
- Fruits should be kept in a shade after picking.
- In the extensive system, yields of 8-15 tons /ha are expected while 15 –30 tons/ha may be obtained from the intensive system.

Diseases and their control

Damping off

- It is caused by pathogens like *Pythium* and *Rhizoctonia*.
- Symptoms include wilting of seedlings with water soaked girdling of the stem at just or just below the soil surface.
- Control is done by good nursery practices and seed dressing with fungicides.

Leaf and fruit spot.

- Caused by fungal pathogens such as *Septoria*, *Alternaria* and *Cladosporium*.
- They cause necrotic lesions round to angular on both the fruit and the leaves and at times the shoots.
- The disease spreads when conditions are wet, humid.
- Affected leaves later die and drop off while the fruits are down graded.
- Good pruning and orchard management is essential to minimise diseases.

. Powdery mildew.

- Causes leaves to turn yellow and drop off.
- The disease is seen as white powdery patches on the underside of the affected leaves.
- Control is by spraying with wettable sulphur.

Phytophthora.

- Causes yellowing of the vines starting at the tips.

- Dark water soaked areas on the stem which develop to swollen areas are the symptoms.
- The swelling becomes corky, dry and the bark gets rough and cracks resulting in wilting and death of the plant. It is a common disease in older plantations.
- Control is done by good drainage and use of chemicals like Bravo, Dithane M45.

Bullets Disease or Mosaic Woodiness

- Is caused by a virus that cause fruits to become lumpy with a thick skin and little pulp.
- Control can be effected by planting virus free seedlings and remove and destroy infected vines.

Anthracnose.

- Occurs where vines have been damaged or cut.
- The tissue near the wound dies, spreading down the plant causing its death.
- Paint cuts and damaged areas with a strong fungicidal solution.

Pests

Fruit fly and Pumpkin fly

- These insects lay eggs in the fruit while the fruit is young and still developing.
- A round depression is formed, with a small hole in the middle.
- A soft brown area develops around the spot.
- Control may be effected by the use of Lebaycid and any other bait spray such as Malathion added with sugar sprayed at four day intervals can also be effective.

Nematodes.

- These are common in sandy soils and affects root growth and development.
- Prevention may be effected by the use of nematicides applied before planting such as 30 ml of nemacur per station

Thrips

- Tiny cigar, shaped insects that can at times be found in large numbers on the flowers of passion fruit.
- Their feeding and egg laying may cause small white blemishes on the fruit.
- They are common in warm dry weather especially in September.
- They cause distorted leaf growth and also flower drop.

Tip wilters

- These are large black stinkbugs with spiny projections on thorax and legs.
- This sap sucking activity causes the wilting and dying of shoot tips.
- Hand collection is the most effective control.

Green stink bugs

- Causes damage by piercing young fruit, that later become discoloured and not of good quality.
- Hand picking is the best method.

Eggplant Production

Background

- The immature fruit is eaten when it is attractively coloured and glossy and the seeds are still immature.
- Fruits are eaten grilled, fried or steamed or stewed with other vegetables, meat or fish or roasted.
- Some cultivars can be eaten raw, made into pickles or sweet jam and can be preserved by freeze drying, canning or deep-freezing.
- It is a good source of vitamin B and C, calcium and iron.

Climatic Requirements

Temperature

- Eggplant is frost sensitive.
- Seed germinates in 7 – 14 days at temperatures of 21 – 24°C.
- Plants should be transplanted when mean daily temperatures have reached 18 – 21°C.
- Maximum growth temperature is 26 – 32°C with night temperatures of not less than 20°C.
- It requires a long growing season of 150 – 160 days and it needs 85 – 90 days to the first harvest.

Soil

- Eggplant requires well-drained fertile sandy loams.
- In sandy soils add manure or compost to improve the organic matter content.
- It requires a pH of 5.5 – 6.5 (CaCl₂).
- Liming is recommended if pH falls below 5.5
- Its susceptible to root knot nematodes therefore avoid old tobacco lands or lands with previous history of nematode infestations.
- Soil fumigation is recommended before planting.

Water requirements

- It has high water requirements and as a rank growing crop should not suffer from water stress at any stage.
- It has a shallow root system with most of the roots occurring in the top 300 mm of soil.
- Light frequent irrigations are recommended.

Table 1: Irrigation schedule for eggplant

	Medium textured soils	Sandy soils	Comments
First month	Apply 30mm net per week	Apply 20 mm net every 5 days	In cloudy or cooler weather increase cycle by 2 days for every 10 mm of rain experienced
Second month to maturity	Apply 40 mm every 6 days	Apply 25 mm net every 3 – 4 days	

- Irregular water supply during fruiting disturbs the calcium supply to the fruit and results in blossom end rot or related symptoms

Land Preparation

Seedbeds

- Grown from seedlings and is not sown directly into the field.
- Prepare raised beds 40 – 50 mm above ground level.
- Apply 4 – 6 kg manure or compost per square meter, 60g single super phosphate, 30 g sulphate of potash and lime if required.
- If manure is unavailable apply 100 – 200 g/m² compound D.
- Seedlings are sown all year round in frost-free areas but in frost areas sow in August to October.
- Seed is sown by drilling 130 – 300 mm apart at a depth of 10 mm.
- A thin layer of grass mulch is beneficial.
- 350 – 500 g of seed is needed to plant 1 hectare
- Transplanting is done 6 – 8 weeks after sowing.

Production of Oyster Mushrooms

The mushroom house

It is also called the Fruiting or Growing house.

Construction of the mushroom house is based on a simple basic design.

1. The dimensions depend on the number of substrate bags the grower can handle at any one time.
2. The walls are constructed out of farm bricks or poles and dagga or a wooden frame and thatch. Plastic or foam sheets may be used to line the walls in order to increase the relative humidity in the production house.
3. A roof thatched with grass or banana leaves.
4. Air vents and windows on the upper side of walls are required for ventilation and lighting to initiate fruiting. Light sufficient to read a newspaper when in the house is adequate.
5. Wooden shelves for holding the bags or wooden racks for hanging spawned substrate bags

The mushroom house should provide optimum conditions for fruiting. Temperatures should be maintained at 18 – 25°C and relative humidity should be 80 – 90%.

Incubation/Spawning Room

- Spawned substrate bags are kept in this room for the mushroom mycelium to grow. Growers may construct a separate incubation room with shelves to hold the bags.
- Alternatively the spawned bags can be covered with a black plastic in the mushroom house.
- If using the mushroom house for incubation the air vents and the windows should be closed to provide dark conditions required for spawning.
- Light is not required in the incubation room. Temperatures should be about 24°C.

Mushroom Spawn

- Spawn referred to, as the mushroom seed is mushroom mycelium growing on sorghum, wheat or barley. It is used to seed substrate.
- High quality spawn should be obtained from reputable Spawn Laboratories
- Good spawn is the key to successful mushroom production. *Pleurotus ostreatus* and *Pleurotus sajor caju* are the strains available locally for Oyster Mushroom production.

Substrates

- Substrate is the agricultural waste on which the mushroom grows. Oyster mushroom can be grown on several agricultural wastes;
 - Finely chopped rice or wheat straw
 - Shredded maize cobs
 - Cotton waste
 - Finely chopped maize stalks
 - Sawdust from broad leaved trees
 - Banana leaves
 - The type to use depends on availability and accessibility.

- Any of these substrates may be supplemented with rice or wheat bran at 15 – 20% and lime at 1 – 2%. Any substrate used must be pasteurised to eliminate contaminants or undesirable organisms.
- A good substrate has the following properties;
- Easy availability
- High nutrient content for the mushrooms to grow
- Good aeration – not too compact and not too loose
- Good water holding capacity – not too dry and not too wet
- Wheat and rice straw are the most commonly used substrates in Oyster mushroom production.

Steriliser

- The steriliser is required for pasteurising the substrate to eliminate pests and diseases.
- The steriliser can be a huge pot, container or metal drum to hold large quantities of substrate for boiling in water at 100°C.
- Firewood or other local materials are used to provide fire for heating the steriliser.

Other requirements

Thermometer – used to check temperatures
 Hygrometer – used for monitoring relative humidity

Sprayer – for watering the substrate during fruiting

- Watering can or bucket – for watering the floor in cooling the temperature and increasing the humidity
- Plastic bags – these are required for containing the substrate during the cultivation process.
- Bags should be 10 – 20 kg capacity and preferably transparent. This makes it easy to check substrate colonisation and to detect contaminants.
- String – required for tying the mouths of bags and for hanging onto racks.

Production

Oyster mushroom production has four major steps.

1. Substrate preparation and pasteurisation
2. Spawning
3. Incubation
4. Fruiting and Harvesting

Substrate Preparation and Pasteurisation

Pasteurisation aims at killing pests and diseases that can spoil development of the mushroom. Immersion in boiling water is a cheap but efficient way of pasteurising the substrate.

1. Prepare the substrate by chopping and shredding into small pieces.
2. Soak the substrate in water overnight.
3. Drain off the water and add the supplements
4. Pack the substrate into a steriliser and fill with water – hot water is the best
5. Heat and pasteurise by boiling for 1 hour.
6. Transfer the substrate onto a clean plastic sheet and cool to about 40°C just at the stage when you can hold it but not get burnt.

7. Pack the substrate into plastic bags taking care not to pack too tightly or too loosely.
8. Add the spawn whilst packing the substrate.

Spawning

This is the process of planting the mushroom.

1. Use about 0.5 kg or 300 ml of spawn to plant 10 kg of substrate.
2. Distribute the spawn evenly in alternating layers with the pasteurised substrate.
3. Tie the mouth of the bag soon after spawning
 - Substrate spawning is the most delicate operation in mushroom production.
 - It must be done in a clean environment free of air movements
 - Care should be taken not to contaminate the spawn itself and the substrate too.
 - Workers must operate under strict hygienic conditions.

Incubation

- During incubation the mushroom mycelium grows to cover the whole substrate.
- Place spawned bags at 24°C in the dark incubation room or cover the bags with black plastic in the mushroom house.
- Bags are ready for mushroom formation when the substrate appears white.
- Full colonisation occurs in about 14 – 40 days.
- Transfer bags to the mushroom house or expose the bags by removing the black plastic.

Fruiting

Fruiting is the formation of the mushrooms in the mushroom house.

- Open the air vents or windows in the mushroom house to provide light and to initiate fruiting
- After one day open the bags by making long cuts or holes at the top and at the bottom of the bags using clean sharp instruments. Mushrooms will form through the openings.
- Mushrooms will begin to form in 3 to 4 days and will be ready for harvesting in the next 2 to 3 days.
- A temperature range of 20 – 28°C and relative humidity of 80 – 95% is required in the mushroom house.
- Some measures have to be taken during the process to ensure development of good mushrooms:
 1. To provide adequate moisture, water the substrate daily taking care not to over water.
 2. If temperatures rise to 30°C apply a light water mist to cool and to quicken fruiting.
 3. The door and air vents or windows may be opened especially at night to allow cool air to enter.
 4. Maintain high relative humidity by applying water on the floors and walls several times a day.

- Incomplete substrate colonisation delays fruiting. Ensure that the substrate is well colonised.

Harvesting

Oyster mushrooms are harvested by gently twisting the stalk and pulling out.

- Harvest from the opened ends first.
- Make more long cuts or holes on the central portion of the bag so that more mushrooms develop
- Continue harvesting as long as the substrate appears white.
- The bags can be removed from the house when the substrate becomes colourless and soft to touch.
- A total weight of 10 to 20 kg of mushrooms can be harvested from 10 kg of dry substrate.
- The mushrooms will remain fresh for 3 to 6 days when kept in the refrigerator or in a cool area. They can also be dried using local methods of sun drying.

Problems in Mushroom Growing

The common problems are:

1. Poor yields
2. Pests and diseases i.e. fungi, bacteria, insects and snails

The best remedy is to prevent these problems by taking precautions in every stage of production.

1. Obtain high quality spawn from reputable sources
2. Observe strict hygienic practices especially at substrate preparation and spawning
3. Pasteurise the substrate well
4. Sterilise all working instruments and equipment. Jik can be used for this purpose.
5. Keep doors and window closed or use a wire mesh for covering all openings to prevent insect from entering the mushroom house
6. Keep the floors clean all the time
7. Do not touch any suspicious material during harvesting
8. Throw used substrate a long distance away from the mushroom house.

Hypericum Production/ Flowers

- Hypericum is propagated from cuttings which are cut from saleable stems 40 cm or more in length.
- Cuttings are cut at every internode and should be 5 cm in length with two nodes.
- Seradix is used to promote rooting and plant cuttings direct into beds.
- The beds should be 1m wide and 4 rows spaced 20 cm apart are marked on each bed.

Fertilisation

Vegetative stage 1: time from planting to 20cm in height

- Hand application of 800g/30 m bed of the following fertilisers mixed to make a blend in the ratio of 1:1
- Calcium nitrate, magnesium nitrate, mono ammonium phosphate, mono potassium phosphate and Ammonium nitrate.

Vegetative stage 2: flower initiation stage

- Apply 1300 g/30 m bed of the fertiliser mixture.
- Supplement with compound J applied every 2 weeks until harvesting at a rate of 600 g/ 30 m bed.
- If rains occur excessively apply weekly

Harvesting

- Harvesting can occur 12 weeks from planting in summer and 16 to 18 weeks from planting in winter.
- Monitor the growth rate daily. Hypericum can grow about 1 cm daily in summer.
- An average of 40 to 50 stem can be harvested per square metre but its possible to harvest 80 to 90 stems/m²
- Stems should be pencil thick when harvested and the stem length varies from 40, 50, 60, 70 and 80 cm
- Harvesting is done when brown berries form on the plant after the flowers fall off.
- Harvest for 7 flushes or less. Each flush is 12 weeks long
- Leave 6 stems per plant as this ensures maximum production. Remove all weak stems
- After harvesting take flowers to pack shed and spray with water
- 5 bunches of 5 stems are bunched together and left till water dries off. Flowers are then packed and cooled to 3 – 4°C
- Harvesting is done in the late afternoon then plants are left to stand in water overnight then grading and packing are done in the morning

Lighting

- 20% shade cloth is used to cover the flowers.
- Artificial lights are used and their use can start as early as one week after cutting back the plants as this promotes faster shooting.
- Recommendations are that lighting should begin when plants are 15 – 20 cm in length.
- Fluorescent lights are used at a height of 3m above the crop. Flood lights can also be used.

Diseases

Rust

- This is controlled using Amister at a rate of 50ml/100 litres water, or Folicur at 50ml/100 litres water, or Plantvax at 100 ml/100 litres water

Botrytis

- Controlled by sterilising pruning shears as one moves from plant to plant and by practicing good hygiene when handling plants

Pests

Thrips – control using Lanet, Oncur or Confidor

White fly

Aphids

Citrus Cultivation

Soils

- Citrus grows well on well-drained sandy soils with clay content of less than 30%.
- Planting should be done on ridges 1 m high and 2.5 m wide and the ridges should go along the slope and not down the slope.

Irrigation

- A citrus need an all year round water supply and irrigation is essential to supplement rainfall.
- Watering depends on two things-:
 1. Age of the tree
 2. Time of year

Age of tree

- The younger the tree the less water it requires.
- As the tree grows the water requirements also increase.

Time of year

- A productive tree of about 10 to 15 years requires up to 120 litres of water per day during the hot summer season around September/November
- .During the cooler seasons from January to April it needs about 10 litres a day.

Types of irrigation

1. Drip

- Used by commercial producers

2. Hose and Basin

- Used by small scale producers

3. Microjet

- Irrigation should be done every third day to avoid water stress.

Altitude

- Des not tolerate frost, thus it should be grown in frost-free areas.
- Effect of temperature varies with the type of citrus being grown, for example Naartijies prefer the cool climate of the highveld around Mvurwi and Nyanga.
- Grapefruit and Valencias prefer the hot climate of the lowveld, while Navels and Lemons prefer the middleveld..

Nursery Practices

- It is recommended that to get the best planting material it should be purchased from established nurseries.

Land preparation

- Citrus can be grown on slopes. The ridges should be prepared running down the slope and should be angled slightly so that they act like contours.

Spacing

Citrus	Between row spacing	In row spacing
Orange	6 m	3 m
Lemon	7.5 m	4 m
Naartijies	4.5 – 5 m	2.5 – 3 m

Cultivar Selection

Cultivar selection is dependant on:

1. Rootstock
2. Citrus type to be grown (This is also affected by altitude)

Types of rootstocks

Rootstock	Advantage	Disadvantage
Rough Lemon (Used on all citrus varieties)	Rapid tree growth Big fruit size	Poor internal fruit quality i.e. low sugar content Susceptible to Phytophthora root rot
Troya (used on all citrus varieties)	Big fruit size Resistant to Phytophthora Better internal fruit quality than Rough Lemon	
Swingle	Good internal fruit quality	Low fruit yield

The scion used depends on the altitude.

Planting time

- Citrus trees are planted from September to February when there is active growth.

Method of planting

- Dig a hole 75 cm x 75 cm x 75 cm.
- Mix 400 g Single Super Phosphate (SSP) with the soil per hole.
- When planting leave about 10 cm of the sleeve above ground level to avoid phytophthora root rot.
- Remove all flowers and fruits produced in the first three years from planting.

Fertilisation

- A tree from 0 to 3 years should get a monthly application of 50 g AN that is watered in.
- Two weeks later apply a foliage spray of zinc, copper, boron and manganese in the following proportions;
 1. Zinc Oxide 150 g/100 litres water
 2. Solubor 100 g/100 litres water
 3. Copper oxychloride 150 g/100 litres water

For productive trees one needs to take soil and foliar samples for analysis before applying fertilisers.

The recommended fertilisers should then be applied from July to January split into equal amounts.

Weeding

- Use of herbicides is strongly recommended in citrus growing.
- The hoe can be used on young trees because use of herbicides at a young age can cause stunted growth

- The area covered by the drip line should be kept weed free, and this is a 1.25 m band on either side of the tree.
- The grass in between the plant rows should be cut short.
- For trees 3 years and above Round up can be used, this is a non-systemic post emergent herbicide.
- Diuron a pre-emergent herbicide can also be used on trees 3 years and above.

Diseases

Phytophthora root rot

- This is a water born fungal disease that attacks the roots. This disease should be controlled early.
- Symptoms: The bark starts cracking from the ground level to the canopy.
- Control: Spray using Alleate or Phytex using rates on the container.

Citrus Black spot

- This is a viral disease that is wind borne. There is no tolerance for this disease on the export market.

Control:

- Spray 2 to 3 prophylactic sprays every year.
- Spray copper oxychloride in September at a rate of 200 g/100 litres water. The copper also benefits the tree.
- In mid-November or when rains start spray Dithane M45 at a rate of 200 g/100 litres water.
- 6 weeks after the November spray, apply Benomyl/Benlate at a rate of 35 g/100 litres water. When spraying add an oil e.g. Orchex at a rate of 100 ml/100 litres water to ensure a good coverage

Pests

Thrips

- These are a problem from September to December.
- Control using Tartox.

Citrus Psylla

- This pest causes greening disease, where the tree does not produce fruit.
- The pest also causes bumps on the leaves.
- Control using Dimethoate or Thiodan

Red Scale

- The levels of this pest should be controlled as high levels can kill the tree.
- It is controlled by spraying with an oil such as Orchex or Lannate.

Mites (Red, spider, grain, silver, rust, lowveld, flat etc.)

- Mites cause damage by leaving marks on the fruit e.g. the rust mite causes the fruit to get a red colour which is undesirable.
- Mites also defoliate the tree.
- Mites can be controlled using Nuron, Torque or Tedion (Tetradifon) at a rate of 30 ml/100 litres water.

Bollworm

- This pest drills holes onto the fruit

False codling moth
Fruit fly

Harvesting

- Harvesting is done at different times of the year depending on the citrus variety being grown.
- Lemons are harvested all year round
- Oranges have different varieties that ripen at different times of the year. For example Navels are harvested from April to May while Valencia's have varieties such as Delta that is harvested in June, Midnight is harvested in June/July and Valencia late harvested in August.
- Naartijies have varieties that ripen at different times of the year.
- Citrus can be stored for 2 to 3 months at a temperature of 4 °C.

Yields

- Mature trees can produce up to 40 to 60 t/ha.

Marketing

There are three ways to market citrus:

- Export – Europe, Russia, Middle East and Canada. To export citrus one needs a marketing agent such as SAFE, OCEANIC, CAPES BAND.
- Local market
- Juicing

Labour requirements

- Labour requirements are seasonal.
- For harvesting and packing there is a high labour requirement
e.g. 30 people for harvesting
30 – 35 people for packing
1 labourer/3 ha fruit depending on management.

Apiculture

- Apiculture means beekeeping for the benefit of mankind.
- The honeybee subspecies found in Zimbabwe is *Apis mellifera scutellata* which is kept for its large quantities of honey.
- Stingless bees also occur but they produce small quantities of honey.

The benefits of beekeeping are: -

- i) Honey production
- ii) Income generation
- iii) Medicinal purposes
- iv) Beeswax
- v) Pollination of crops
- vi) Propolis
- vii) Employment creation
- viii) Rural afforestation and woodland management programmes

Honeybee colony

A honeybee colony is the whole family of bees with combs and brood living in a hive or natural nest.

Queen

- This is the mother of all the honeybees in a colony and can live for 3 – 5 years.
- She has a curved sting that she uses against other queens.
- Her abdomen extends beyond the tips of her wings. The younger the queen the more eggs she should lay. A good queen lays about 2000 eggs/day during the nectar flow.
- The queen emerges from a peanut shaped queen cell
- She maintains harmony in a bee nest or beehive by releasing pheromones that suppress the development of ovaries in worker bees.

Workers

- Found in large numbers of up to 80 000– 100 000.
- Smallest of the three bee castes
- They are females but they do not lay eggs in the presence of the queen
- They emerge from worker cells
- They defend the nest or hive from intruders
- They collect nectar and pollen
- They feed the brood and the queen with protein rich food.
- Life span is 4 – 6 weeks during the busiest time of the year
- They have barbed straight stings.
- Worker bees have long tongues (proboscis) for collecting deep seated nectar.

Drones

- Their only known function is to mate with young queen bees
- Mating occurs in the air and immediately after mating they die.
- In winter when food is scarce they are driven out of the bee nest by the worker bees.
- Drones have no stings and therefore cannot defend themselves

Traditional beekeeping with the use of bark or log hives

Advantages

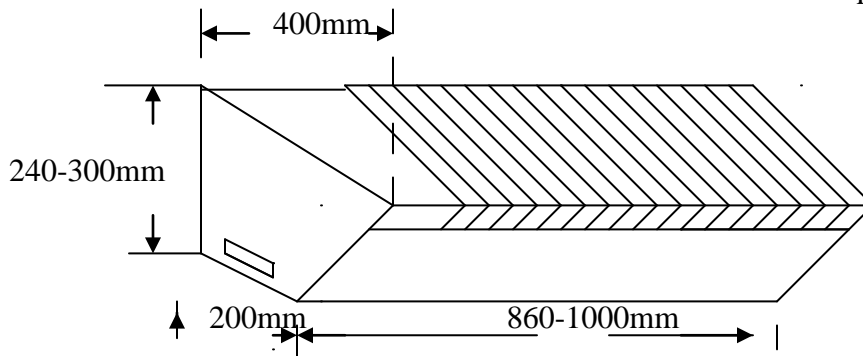
- Initial cost is very low
- More beeswax obtained
- Familiar to many people

Disadvantages

- Difficult to control bees
- More wasteful
- Traditionally unacceptable for women in some parts of Zimbabwe as the system demands climbing up trees when harvesting honey.
- Causes depletion of forests through beekeepers stripping bark to make beehives
- Beehives do not last long

Movable Top Bar Hives (Kenya Top Bar Hives)

This is a beehive that is narrower at the bottom and wider at the top



Advantages

- Simple to construct
- High honey yields of up to 80kg/ cropping can be obtained
- Durable
- Easy to control bees
- Good quality honey can be obtained
- High beeswax yields can be obtained
- Only capped honey is cropped
- Combs are interchangeable

Disadvantages

- Cost of timber is high
- Combs can easily break if not carefully lifted

Greek Basket Top Bar Hive

- The walls are plastered with a mixture of two parts cow dung and one part ant heap soil.

Advantages

Can be made of locally available material such as reeds or straw

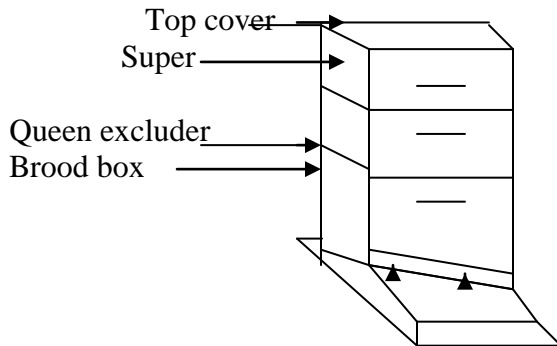
- More beeswax obtainable.
- Honeybees can be easily handled
- Only ripe honey can be cropped

Disadvantages

- Combs can easily break if not properly handled
- Brood and honey can be mixed
- Top cover needs replacement very often.

Frame Hives

The most commonly used frame hive is the Langstroth Frame Hive
It consists of boxes with frames stacked one on top of each other



Advantages

- High yields of honey can be obtained
- Honey not mixed with brood
- Combs are interchangeable
- Boxes are durable
- Easy to control bees

Disadvantages

- Costly
- Not familiar with beekeepers
- Needs mechanical honey extraction

Site selection

- Vegetation cover should provide forage for the honeybees, shade for the beehives and protection from prevailing winds.
- There must be a consistent water supply in or close to the apiary for cooling the hive and for dilution purposes.
- The site should have minimal danger from veld fires.
- Easy accessibility to the site in all weather by the beekeeper.
- Free from disturbance by animals.
- A place where honeybees do not become a nuisance to the public
- Avoid frost pockets such as vleis to avoid chilling of brood in winter.

Setting beehives

Materials required for setting beehives:

For beehive setting to be successful the following materials are required:

- Propolis for attracting.

- Beeswax for top bar lining.
- Wax foundation sheets or strips for honeybees to draw out combs
- Top bars for placing on top of the beehives
- Frames for the brood or super cambers
- Small tin for melting wax.
- Guiding plank for straightening the wax linings on the top bars
- Bucket of cold water for dipping the guiding plank and holding excess wax
- Firewood for making fire required to melt propolis and beeswax.

Setting Top Bar and Frame Hives

The following steps should be taken when setting both Greek and Kenya Top Bar hives:-

- Prepare a small fire
- Melt propolis in a container
- Smear melted propolis on the hive entrance and the inside of the hive walls
- Draw a centre line along the entire lengths of at least eight top bars on a Kenya Top Bar Hive and about four top bars on a Greek Basket Top Bar Hive.
- Melt beeswax in container but do not overheat.
- Submerge the guiding plank in water and hold it against the centre line on the dry top bar.
- Tilt them with the lower end pointing into the bucket with cold water.
- Pour melted wax so that it flows following the centre line marked on the dry top bar to form a wax ridge and let the wax lining to cool down.
- Remove the guiding plank and scrap off about 5cm lengths from both ends of the top bar that will rest on the hive body.
- Place all top bars with wax ridges starting from the front of the Kenya Top Bar Hive.
- Place the rest of the top bars without wax ridges up to the end of the beehive
- For a Greek Basket Top Bar Hive place top bars with wax ridges starting from the centre and they should be placed at right angles to the hive entrance.

Factors to Be Considered When Mounting Top Bar and Frame Hives

- Place hive at a workable height.
- Hive entrance to face leeward side to prevent draughts.
- Place hive under shade to prevent the hive from direct heat of the sun.
- Top of hive to be covered with a roof top..
- Consider security from enemies of honeybees

Handling honeybees

Steps to follow when manipulating honeybee colonies

- Put on the complete bee tight suit consisting of: -
 - A zip up overall
 - Jacket
 - Hat and veil
 - Gloves
- Light the smoker and ensure that there is a smooth flow of smoke

- Approach the hive from the back or side.
- Apply 3-4 gentle puffs of smoke into the hive through the entrance.
- Wait for a few minutes to allow honeybees to engorge honey.
- Remove roof top for top bar hives and the top cover for frame hives.
- Start lifting top bar hives using a hive tool. Start from the back for a Kenya Top Bar hive and from sides for both frame and Greek Basket Top Bar hives.
- Smoke should always be available and apply gentle puffs at regular intervals to control the temper of honeybees. A beekeeper should be assisted to make the work easier.

Brood Nest Inspection

- Inspect the brood nest 2- 3 times a year especially during the swarming season
- Inspect the hive in winter as briefly as possible to prevent chilling the brood and robbing of honey by bees from adjacent beehives
- Push light honeycombs to the empty side
- Take out the darker combs and examine one by one but not exposing them to the cold wind or sun.
- Look for eggs, larvae and pupae to ensure the presence of the queen bee but brood can be absent as the queen reduces egg laying at this time of the year.
- Place the top bars back onto the hive in the same order and position to maintain the structure of the hive or nest.
- Place combs with drone brood cells to the edge of the brood nest on the empty side of the hive.
- Spare valuable space of the brood nest especially 1-8 combs mainly for new workers instead of unproductive drones.
- Remove crooked combs, very black ones or combs with large patches of drone brood from the brood nest.

Cropping

- Take only combs with capped honey. Uncapped honey contains too much moisture in excess of 17%, which can lead to fermentation of honey soon after cropping.
- Do not take any combs containing brood.
- In the case of combs from top bars, crop when 75% of a single comb has capped honey.
- Cut off the capped portion and tie back the portion with brood on the same top bar.

Grading

- Grading of honey starts at cropping.
- There are four grades of honey based on colour, aroma, flavour and moisture content.

First Grade

- New wax combs
- Light coloured honey
- No pollen grains
- Acceptable flavour/aroma

- Low moisture content

Second Grade

- New wax combs
- Medium light honey
- Very little pollen
- Few uncapped cells/honey (80% capped)
- Acceptable flavour/aroma
- Low moisture content

Third Grade

- Mostly new combs
- Light brood combs
- Small amount of uncapped cells
- Acceptable flavour
- Low moisture content

Fourth Grade

- Old combs
- Dark honey
- Pollen present
- Doubtful flavour
- Medium moisture

Marketing

- Honey is in comb or liquid form and prices are determined by the grades.
- Marketing is controlled by legislation.

Methods of honey extraction

Floating.

- Break honey combs into small pieces.
- Tie the broken combs in a cheese cloth
- Hang the cheese cloth in a warm room and honey will slowly drip into a clean bucket placed below.
- Leave the honey to drip overnight.

Centrifuging

Centrifuging is ideal for extracting honey from frame combs

- Uncap the combs using a hot uncapping knife
- Place the uncapped frames in an upright position in a mechanical honey extractor.
- Place settling tank with strainer below the outlet and start centrifuging.
- Honey collects in the settling tank
- Settle honey for at least 10 days to allow air bubbles and impurities to float.
- Scoop out the impurities and honey will be ready for bottling.

Enemies of the honeybee and control

i) Man

Destroys the honeybee and its habitat

Control:

- Education
- Law enforcement
- Keeping honeybee colonies in Bee Houses

i i) Bee wolves (wasps)

The females use the adult bee as food for their larvae. It catches the bee at the hive entrance.

Control:

- Usually difficult
- Water with a film of paraffin in a dish and placed close to the hive entrance is used for trapping bee pirates. The bee pirate plunges in water on seeing its image in the paraffin film. A few honeybees will be lost but the loss can outweigh the advantages obtained from the elimination of the bee pirates.

iii) Honey Badgers (Mellivora capensis)

- Its skin is loose and so tough that the dog's teeth cannot penetrate.
- It has strong claws for digging and strong teeth for biting and breaking hives.
- Badgers do not suffer from stings. They overrun hives, break them up and feed on the brood and honey.

Control:

Trap or hunt to shoot them
Secure the beehives

iv) Wax Moth (Galleria mellonella)

- The larvae of the wax moth feeds on combs Weak colonies are vulnerable to attack by the wax moth larvae.
- Growing larvae construct silk lined tunnels through the cell walls. Larvae prefer dark combs because they contain a variety of growth enhancing impurities such as entrapped pollen and cast larval skin.
- Mature larvae usually spin cocoons in oval depressions that they chew on the inside of hive bodies, inner cover, lid and on frames. They even make some deep furrows on top bars and the inside of Kenya Top Bar Hives.

Control

Maintaining strong colonies
Avoid queenlessness of colonies
Put infected combs in freezers for about 48 hours
Carbon dioxide fumigant

v) Large Hive Beetle (Coleoptera)

The beetles interfere with the activities of honeybees as they gather at beehive entrances, crawl on combs and hive floors. They also feed on wax leaving combs very thin.

Control:

- Control is difficult but honeybees propolise them
- Hand pick and throw them in soapy water.

vi) Ants (Hymenoptera)

- Especially the tropical ants are serious pests
- They steal honey, bee brood or live in the colony where honey bees cannot remove them.

Control

- Hive stands should have ant guards such as barriers of grease.
- Chemical control can be hazardous but when mixed with water can be applied around hive stands.

vii) Spiders

- Several kinds of spiders eat honeybees. Others construct a large web to trap flying insects like honeybees.

Control

- Remove webs from the bee flight areas.

vii) *Varroa mites*

- They feed on the blood of larvae, pupae and the adult insects

Control

- Contact acaricides are used in the form of strips placed between top bars.

viii) *Braula coeca (Bee louse)*

- These are wingless flies that attach themselves to the bees' hairs near the head or thorax. They feed on nectar and pollen at the bee's mouth.
- A queen is likely to collect more bee lice than the worker

Control

- Blowing tobacco smoke into the hive can make the flies leave the queen.