CITRUS GROWER'S MANUAL

Scientific name: *Citrus Sinensis*



1.0 Introduction

Citrus is an evergreen tree reaching a high of 5-15 m tall, belonging to the family Rutaceae. It has about 150 genera and 1500 species, all native to the tropical and subtropical regions of Asia. Citrus is a wider name for several species such as pomelo, lemon, citron, pixie, tangerine/ mandarin among others.

Citrus remains a vital horticultural crop in Kenya. Pixie orange are the main citrus species that are grown commercially. Demand of citrus is so high that local production cannot meet the demand leading to the importation of large quantities. Citrus yields in Kenya started showing signs of decline from as early as 1970s due to the Citrus Greening Disease which killed most trees in orchards especially in the highlands

1.1 Uses

Many citrus fruits, such as pixie, tangerine and grapefruits are eaten fresh or processed into juice. They are rich in Vitamin C and Antioxidant. Lemonade or limeade is popular for beverages prepared by diluting the juices of lemon and lime and adding sugar. Lemons and limes are also used as garnishes or in cooked dishes. Marmalade is a condiment derived from cooked orange and lemon, and is usually sweetened to cut the bitterness and produce a jam. Lemon or lime is commonly used as a garnish for water, soft drinks, or cocktails.

1.2 Citrus varieties

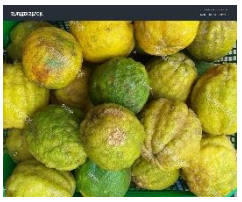
a.) Scions

Pixie, Washington navel, valencia, tangerine, mandarin (C. reticulata) lemon (C. limon),Lime (C. aurantifolia] grapefruit (C. paradisi)pomelo (C. grandis) rough lemon (C. jambhiri)sour orange (C. aurantium)cleopatra mandarin (C.reshni Hort.)

b). Rootstock

Rough lemon (C. jambhiri) Sour orange (C. aurantium) Cleopatra mandarin (C.reshni Hort.)

Citrus varieties description as per the table below

No	Varieties	Fruit description	Photo
1	Washington navel	Fruit rind is medium thick tender flesh deep orange firm less juicy, rich in flovor and taste, not for processing. Large in size slightly elongated Ships and stores well, seedless	 Photo: Oxfarm organic limited
2	Pixie	Yellow orange color fruit, moderately juicy and always seedless, fruit are small 1-3 inches in diameter, pebbly skin and easy to peel, fruits are aromatic and low acid	 Photo: Oxfarm organic limited
3	Valencia	Fruit medium round slightly oval, sweet flavor orange color, very juicy ,few seeds or none, easy to peel smooth deep orange colored rind	 Photo: Wikifarmer
4	Lemon	Fruit is oval with smooth or bumpy porous skin with pointed tip or round base greenish yellow to bright skin color	 Photo: Oxfarm organic limited

5	Lime	Fruit round green in color 3-6 cm diameter contain acidic juice	 Photo: Farmlink
7	Grape fruit	Fruit is large, thick peel, fruit is bittersweet to sour fruit is spherical in shape pale yellow or reddish smooth or rough	 Photo: Shutterstock
9	Tangerine/mandarin	Fruit small, juicy and aromatic pulp	 Photo: Oxfarm organic limited

Table 1. Citrus varieties

1.3 Counties where grown

In Kenya, the major production counties are; Makueni, Machakos, Kitui, Taita taveta, Muranga, Nyeri, Lamu,Kwale Siaya, Tharaka nithi, Embu, Baringo , Nyanza, Garrisa and Elgeyo marakwet

1.4 Ecological requirements

Altitude - 0 -1800m above sea level

Temperatures - from 20 °C to 34 °C annually.

Average rainfall- 1000mm annually

Soils -deep soils of medium texture with good drainage and high fertility and moderate pH of 5-7

2.0 Good Agricultural Practices (GAPs)

Horticulture industry in Kenya is guided by a code of practice KS1758 which is a standard for flowers, vegetable, fruits, herbs and spices for both local and export market. The standard aims at ensuring food safety, environmental sustainability and social accountability by following good agricultural practices from production, processing, transportation and marketing of fresh produce

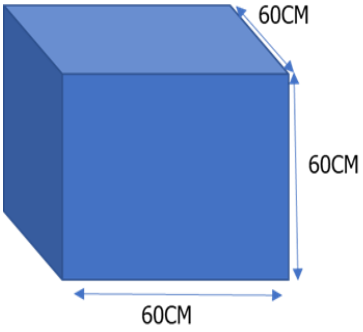
The manual seeks to adopt climate smart technologies aimed at increasing production and productivity, enhancing resilience and reducing GHG emissions.

2.1 Crop establishment

Prepare a planting calendar based on market survey which will guide on when to cultivate, varieties, quality and quantities required**.**

2.1.1 Land preparation

Ensure that all debris and unwanted vegetation are removed. Prepare planting holes about 60 x 60 x 60 cm during the dry season and separate top soil and sub soil.



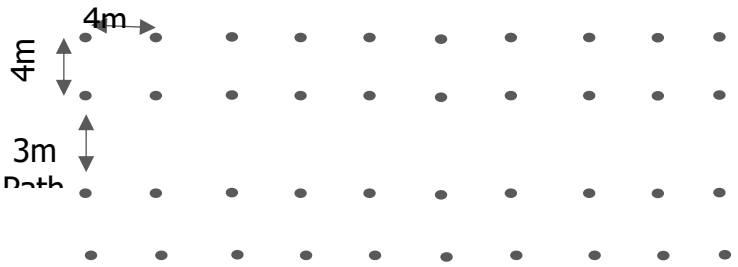
2.1.2 Soil and water testing

The testing is recommended before planting to guide on fertilizer and manure application and water suitability for irrigation

2.1.3 Planting and spacing

Source of planting materials should be from certified sources or registered nurseries.

Spacing range from 4m x 4m to 6 x 6 m depending on growth characteristic of the individual variety and the type of soil.



Fill the holes with topsoil mixed with 20kg manure and 100kg DAP or TSP fertilizer. Water the holes unless the soil is wet enough. Excavate soil at the center of the hole and plant the seedling firmly press soil at the base and add more soil up to the same depth as seedling was in the nursery. The bud union should be about 30cm above the ground to avoid exposing the scion to root rot diseases and unsure it does not start rooting itself.

2.2 Crop Management

2.2.1 Crop water requirement

This depends on crop water requirement which is determined by the stage of the crop, soil type and prevailing climatic conditions

Citrus tree is capable of withstanding long period of drought, however irrigation is important during initial stage, (young trees) during and after flowering to ensure sufficient water for fruit set and growth.

General irrigation for grown-up plants at 7-10 days interval during hot months and depending on the type of the soil is recommended. Drip irrigation is efficient and economical way to water.

2.2.2 Crop Nutrition

The amount of fertilizer to be applied will generally depend on the fertility of the soil in question after soil test is done. The following rates of Nitrogen application per tree are recommended as per the table below

CAN/kg	**1st year**	**2nd year**	**3rd year**	**4th year**	**5th year**
	100g	250g	400g	550g	700g

Table 2. Citrus fertilizer application rates

A subsequent yearly application of 1.2kg nitrogen in mature orchards will maintain a high level of production. The nitrogen quantities should be split and applied 1-2 weeks after the onset of the long and short rains. Phosphorous should be applied as single superphosphate from the 3rd year. The following rates per tree are recommended as per the table below

SSP/kg	**3rd year**	**4th year**	**5thyear**
	250g	600g	600g

Table 3. Citrus fertilizer application rates

Add 1.5kg TSP/tree in subsequent years.

Potassium is important as a fruit sweetener. Applications of up to 600-750g, of potassium per year for a mature tree in split applications will improve fruit quality if there is deficiency. Soil testing will show whether a potassium application is necessary. On acidic soils 1-2kg of agricultural lime can be applied per tree spread evenly over the soil covering

2.2.3 Weeding and mulching

Control weeds that compete for fertility and moisture. If tools or machines are used, injuries on the tree trunks and roots must be avoided, as they may become entry points for soil-borne diseases so shallow weeding or herbicides is recommended.

Mulching of new plants during the first establishment period is essential

2.2.4 Pruning

Initial pruning

Prune and train citrus trees by maintaining a single stem up to a height of 3 feet (100 cm), and pinch or break the main shoot to encourage side branching, then allow 3 to 4 main branches to form the framework of the tree.

Maintenance pruning

Remove any extra side branches including those growing inwards, ensure all diseased and dead branches are removed regularly. Annual pruning maintains light and air penetration through the canopy of the citrus trees and reduces the humidity around the plants

contributing to pest and disease prevention. Maintain tree height at less twice the planting distance in the row. Pruning should be done during the vegetative phase.

2.2.5 Pest and Disease Management

Major pests and diseases

Integrated crop management (ICM) is the best option for food safety. These practices include scouting of pests, field hygiene, proper spacing, physical methods, and biological methods like use of pheromone traps and others that will only give option of using Pest Protection Products as last option. The products must be registered for use on the crop in Kenya. (www.pcpb.go.ke/list-of-registered-products/

Pests /diseases	Symptoms	Control
Citrus Aphid *(Toxoptera citricidus)*(***Black Citrus Aphid***) *and* (***BrownCitrus Aphid***) *(Toxoptera aurantii)*  Photo: infonet-biovision	They cause growth distortion by sucking plant sap. Honey dew and sooty mould is usually present. Citrus aphids transmit Tristeza and other viral diseases. Stems of young shoots die back	Natural enemies such as lady bird Use recommended insecticide such as ,abametin,deltamethrin,lambda cyhalothrin,acetamiprid,emametin
Citrus Psyllid *(Trioza erytreae)*   Photo: UF/IFAS Extension-University of florida	Pits on the underside leaves Raised bumps on the upper side of the leaf. The leaf blades are distorted and yellowish in color. The psyllid is vector of the greening disease.	Rogue infected plants, Water and fertilize trees in early stages. Remove other host crops which are wild Use recommended insecticide e.g abametin, deltamethrin, lambda cyhalothrin, acetamiprid,emametin

SCALES Red scale *(Aonidiella aurantii)*  Photo: Plant care today	Dis-coloration of foliage and branch die back. Black sooty mould on Fruits and leaves.	Cut and burn infested tree parts Use natural enemies e.g. parasitic wasps, lady bird beetle, lace wings Use white oil plus appropriate insecticides abametin,deltamethrin,lambda ,cyhalothrin, acetamiprid, emametin
Fruit Flies (*Ceratitis ap itata)* and *(Ceratitis rosa)*   Photo:Cabi International / plantwise	Spots develop on the skin where eggs were laid and on hatching the larvae enter the fruit. On immature fruits, The attacked area becomes soft, turns brown and decays.	Destroy all infested fruits Use of pheromone traps Use of parasitic wasps
False Codling Moth *(Cryptophlebia leucotreta)*  Photo: A.M Varela Icipe	Caterpillars which are white and later turn pink in the fruit. They penetrate into the pulp causing a yellow patch on fruit skin around the entry point	All infested fruits both fallen and on trees, should be destroyed by burying not less than 50cm deep. -Uses of pheromone traps -Uses of parasitic wasps
Spider mite (*Tetranychus spp)*  Photo: SA Fruit journal	Leaves chlorosis and deformation of leaves. Attacked green fruits become bronze to dark brown.	Numerous natural enemies such as predatory thrips, lady birds and predatory mites normally attack the mites. Use recommended miticides such as Abamectin

Citrus greening caused by the bacterium (*Candidatus Liberibacter)*  Photo: africanus University of florida	Tree stunting, leaf and fruit drop, and twig die-back.Usually, only one of a few branches is affected while the rest of tree appears normal. Affected fruits are small, poor quality, lopsided, drop prematurely. There is interveinal chlorosis. Out of season blooming.	Use clean planting material Nurseries should be established only in areas below 800m in altitude Maintain proper hygiene among workers and tools
Root Rot & Gummosis cause fungi *(Phytopthoraspp)*  Photo: UCANR-tropic and subtropic  Photo:A.A Seif icipe	The foliage turns yellow and drops while twigs die-back. An early symptom is the sap oozing from small cracks in the infected bark giving the tree a bleeding appearance	- Treat citrus seeds with hot water at 50° C for 10 minutes - Drench soil with recommended fungicide e.g. Allieta 80 WP - Use tolerant or resistant rootstocks. Trifoliate orange, sour orange Cleopatra mandarine, rough lemon, - Bud seedlings at a height of 25 cm above the soil -Avoid poorly drained soils. - Do not heap soil around the tree base. - Avoid injuries to roots and trunks when cultivating. -Bark surgery before 50% of the trunk is affected, this is removing about 10mm margin of healthy bark tissue and painting

		the wound with a slurry of copper-based fungicide.
Leaf spot & fruits spot cause; fungus *(Phaeoram angolensis)*   Photo: Cabi International/plantwise	On leaves, this is observed as circular, mostly solitary spots with a yellow halo. On young fruits, brown necrotic lesions form.	Use recommended fungicide e.g. Copper oxychloride,Azoxystrobin, Tebuconozole

Table 4: Citrus pests and diseases

Nutrients deficiency

Nutrient/ element	**Symptoms**	**Control**
Nitrogen  Photo:University of florida	Pale yellow to old ivory leaves	Foliar application of urea nitrogen fertilizer(urea) to trees
Phosphorus  Photo:University of florida	Fruit are coarse with thick rind, low juice level, older ,leave turn yellow	Apply water soluble phosphorus fertilizer to the soil
Magnesium  Photo:University of florida	Yellow, mottling along margins developing a green wedge "Christmas tree" pattern. Eventually complete yellowing and defoliation	Apply foliar spray of magnesium chelates to trees

Iron  Photo: University of florida	Yellow veins; remain green until final stage of general chrolosis.	Apply foliar spray of iron sulfate or iron chelate
zinc  Photo: University of florida	Mottled yellow between main veins.	Apply foliar spray of iron sulfate or iron chelate
Potassium  Photo: University of florida	Old leaves curl and lose their green color	Apply sulphate of potash to the soil.
Copper  Photo: University of florida	The first symptom of Cu deficiency is formation of unusually vigorous, large, and dark green foliage with a "bowing up" of the midrib. Twigs are also unusually vigorous, long, soft, angular, frequently S-shaped, and somewhat drooping, Acute deficiency cause twigs to die. Some of the weak twigs will bear very small, yellowish-green leaves that drop quickly, leaving the twig defoliated.	Apply copper foliar spray to trees or copper fertilizer to the soil

Table 5. Citrus nutrients deficiency

2.3 Harvesting

2.3.1 Maturity indices

The first economic crop is expected 3-4 years after transplanting. Citrus has 2 picking seasons each year in Kenya; June-July and December-January. Oranges, grapefruits, tangerines are picked when fully mature and when uniform orange color is observed. In areas where the fruit remains green, it is necessary to test a few for ripeness.

2.3.2 Harvesting method

The fruit is harvested individually either by clipping off the stalk or by bending and pulling with a light twist. Care should be taken not to injure or bruise fruit as that leads to rapid spoilage. Limes and lemon are picked when green. Mature fruits change color when night temperature is about 14°C coupled with low humidity

2.3.3 Expected yields

Yields vary according to the variety. The following yield range per 4-year tree per season may be obtained.

Variety	**Yield(kg)/tree**
Orange	200
Pixie	250
Lemon	180
Grapefruit	250
Lime	120

Table 6. Citrus yields

2.4 Post-harvest handling Activities

Post-harvest activities should be done to maintain quality.

2.4.1 Sorting and grading

Citrus fruits for market should be clean and free from dirt, traces of pesticides and blemishes. Oranges and grape fruits are graded according to fruit diameter (using a roller grader) in to three respective sizes as follows:

Variety	Grade I	Grade II	Grade III
	(Large)	(Medium)	(Small)
Oranges	Over 8cm	8.0 -6.5cm	Below 6.5cm
Pixie	0ver 7cm	5cm	Below2.5cm
Grape fruits	Over 10 cm	9.9 -8cm	Below 8.0cm

Table 7. Citrus grades

2.4.2. Packaging

Citrus fruits should be of uniform size and weight in each container. They should be packed in clean crates

2.4.3 Transportation

Citrus fruits should be transported in closed trucks as per the Crops (Horticultural crops) Regulation 2020. This is to avoid direct sunlight and dusts for food safety and quality concerns. Transport during cooler part of the day or use refrigeration where possible.

2.4.4 Marketing

Citrus fruits are mainly sold in the local markets for fresh consumption while Grape fruits and lemons are bought by the canning factories for making marmalade.

3.0 Gross margin analysis for 1 acre (Washington navel) as at 2024

NB: 1 acre has 256 trees, spacing of 4mX 4m

Item	Units	Quantity	Cost /unit	Total cost ksh	Total Amount in (Ksh)			
					Year 1	Year 2	Year 3	Year 4
Gross income	Kgs	256	100	-	-	768,000	2,560,000	3,840,000
Production cost								
Variable costs								
Land Preparation	Acre	1	5,000	5,000	5,000	-	-	-
Soil analysis	Sample	1	2,500	2,500	2,500	-	-	-
Seedlings	Sample	256	300	76,800	76,800	-	-	-
Holes	No.	256	50	12,800	12,800	-	-	-
Manure	Tons	1	4,000	4,000	4,000	8,000	10,000	10,000
Planting	Acre	1	4,000	4,000	4,000	-	-	-
Fertilizer CAN	Kgs	25	120	3,000	3,000	2,400	4,500	6,000
Fertilizer TSP	kgs	50	120	6,000	6,000	2400	4,500	6,000
Farmyard Manure	bags	20bags	100	2,000	2,000	2,000	2,000	2,000
Foliar fertilizer (boron and potassium)	mls	500ml		-	-	1,500	2,000	2,500
Fungicides /insecticides	mls			20,000	20,000	20,000	20,000	20,000
Fruit fly traps (pheromone traps)	No	26 traps	800	20,800	20,800	20,800	20,800	20,800
Stickers	No.			10,000	10,000	10,000	10,000	10,000
Casual Labor cost,	Casual	2	8000	192,000	192,000	192,000	192,000	192,000
Tools (jembe, panga, secatures, prunning shear, wheelburrow)	Ksh	Assorted		50,000	20,000	-	-	-
Crates	Pcs			20,000	20,000	-	-	-
Total variable costs				**428,900**	**428,900**	**259,100**	**265,800**	**275,000**
Gross margin (gross income — total variable costs)						**508,900**	**2,294,200**	**3,568,500**

Gross margin analysis for 1 acre (Pixie) as at 2024

Item	Units	Quantity	Cost /unit	Total cost ksh	Total Amount in (Ksh)			
					Year 1	Year 2	Year 3	Year 4
Gross income	Kgs	256	150	-	-	1,920,000	5,760,000	9,600,000
Production Cost								
Variable costs								
Land Preparation	Acre	1	5,000	5,000	5,000	-	-	-
Soil analysis	Sample	1	2500	2,500	2,500	-	-	-
Seedlings	Sample	256	300	76,800	76,800	-	-	-
Holes	No.	256	50	12,800	12,800	-	-	-
Manure	Tons	1	4,000	4,000	4,000	8,000	10,000	10,000
Planting	Acre	1	4,000	4,000	4,000	-	-	-
Fertilizer CAN	Kgs	25	120	3,000	3,000	2,400	4,500	6,000
Fertilizer TSP	kgs	50	120	6,000	6,000	2,400	4,500	6,000
Farmyard Manure	bags	20	100	2,000	2,000	2,000	2,000	2,000
Foliar fertilizer (boron and potassium)	ml	500		-	-	1,500	2,000	2,500
Fungicides/insecticides	ml			20,000	20,000	20,000	20,000	20,000
Fruit fly traps (pheromone traps)	No	26 traps	800	20,800	20,800	20,800	20,800	20,800
Stickers	No.			10,000	10,000	10,000	10,000	10,000
Casual Labor cost,	Casual	2	8000	192,000	192,000	192,000	192,000	192,000
Tools(jembe, panga, secatures, prunning shear, wheelburrow)				50,000	20,000	-	-	-
Crates	Pcs			20,000	20,000	-	-	-
Total variable costs				**428900**	**428,900**	**259,100**	**265800**	**271500**
Gross margin (gross income — total variable costs)						**1,624,900**	**5,494,200**	**9,328,500**

Table 9. Gross margin analysis for pixie citrus variety

References

1. Kilalo, D., Olubayo, F., Obukosia, S., & Shibairo, S. I. (2009). Farmer management practices of citrus insect pests in Kenya.

2.Gitahi, D. W. (2018). *Evaluation of knowledge and practices of managing citrus pests and diseases and the willingness to pay for an integrated pest management strategy in selected Counties in Kenya* (Doctoral dissertation, Egerton University).

3.Manner, H. I., Buker, R. S., Smith, V. E., Ward, D., & Elevitch, C. R. (2006). Citrus (citrus) and Fortunella (kumquat). *Species profile for pacific island agroforestry*, *2*, 1-35.

4. Ouko, J. O., & Abubaker, A. S. (1985, November). Evaluation of citrus rootstocks in coast province of Kenya. In *XII African Symposium on Horticultural Crops 218* (pp. 43-50).

5.Otieno, H. M. (2020). Simplified orange (Citrus spp.) production guide for small-scale farmers. *Asian Journal of Agricultural and Horticultural Research*, *5*(1), 23-27.

6.Munywoki, J. M., & Munywoki, G. N. (2022). IASR Journal of Agriculture and Life Sciences.

7. Tennant, P. F., Robinson, D., Fisher, L., Bennett, S. M., Hutton, D., Coates-Beckford, P., & McLaughlin, W. (2009). Diseases and pests of citrus (Citrus spp.). *Tree and Forestry Science and Biotechnology*, *3*(2), 81-107**.**