2.3.1 SUB-MODULE 1: CROP VALUE CHAINS SUITED FOR ASAL AGRO-ECOLOGICAL ZONES

The need for identification and targeting of crops and crop varieties suitable to different agro-ecological zones cannot be overemphasised for increased agricultural productivity and output. Inadequate information and skills as well as poor market information makes it difficult for farmers to engage in certain crop enterprises. This sub module provides guidance on the relevant skills and information needed to promote crop value chains for the targeted agro ecological zones. For the crops not captured in the manual, further readings and references can be accessed through; https://kalro. org/kcsap/index.php/resource-centre/pricing-table/latest-items

Sorghum (*Sorghum bicolor*)

Sorghum crop (Photo: Sorghum extension Manual, KALRO.org)

Sorghum is a member of the grass family, grown majorly for the seed/grain as human food and foliage for livestock. It is a drought tolerant crop and is an important food and nutritional security crop especially in semi-arid lands (SALs). The grain is high in energy and nutritional levels, suitable for consumption by all. Grains can be boiled, ground for *Ugali* and porridge, malted for beer, baked, popped for snacks, among others. Sorghum has the ability to ratoon after harvest which minimises the costs of land preparation and planting. Production varies from 8-26 bags of 90 kg per acre, depending on the variety and other extrinsic factors.

Ecological requirements

Sorghum is relatively drought resistant and therefore does well even in drier areas. This is done through the survival tactic and adaptation mechanism where the plant rolls up its leaves to reduce the transpiration rate.

- Soil: The crop requires a fairly fertile soil which is well drained, clay-loamy soils and a PH of 5.0-8.5
- Rainfall: An annual rainfall of 250-900 mm is adequate for optimal production of sorghum. The crop is resistant to waterlogging
- Altitude: The crop grows well in the range of 500-5500 m
- Temperature: Warm temperatures of between 15-35 ^{o}C is ideal for the sorghum's growth and development.

Selected varieties

The varieties (Table 2.2) are characterised majorly by seed colour, taste, maturity, adaptation and yield potential. The choice of appropriate sorghum varieties therefore, is very important since specific attributes based on climatic conditions, yield potential, resistance to pests and diseases, maturity period, household utilisation and market preference are considered.

Table 2.2. Sorghum varieties and special attributes

Variety	Seed colour, attributes	Maturity	Yield (kg)
Gadam	Grey, high malting quality	85-95 days	1000-1800
Seredo	Brown, bird tolerant	110-120 days	1000-4000
Serena	Brown, bird tolerant	110-120 days	800-2500
Mtama 1	White, high malting quality	95-100 days	2500-4000
Mtama 2	White, high malting quality	95-100 days	1000-4000
E 1291	Brown, good for sorghum beverage	150-210 days	2000-4000
E 6518	Brown, dual purpose, high quality fodder	210-240 days	1500-3800
IS76	White/brown, medium yielding	90-110 days	1800-2800
BJ28	Brown, dual purpose suitable for grain and forage	150-210 days	1000-3800

Agronomic practices

Land Preparation and Planting. Sorghum is propagated by seeds. Land should be prepared well in advance during the dry condition and planting done at the onset of rains. The recommendation is to plough the land immediately after harvesting the previous crop. Ploughing should also be done to a fine tilth. Planting is done either by Seeds broadcasted or sown directly into furrows on the well-prepared seedbed. Plant at a depth of 2.5-4.0 cm when the soil is moist and 5 cm when dry. The spacing differ in that, when planting sorghum as a sole crop, the spacing should be 90 by 15 cm or 75 by 20 cm.

Intercropping. Intercropping with legumes, the spacing should be 90 by 20 cm for single alternate rows and 120 by 20 cm for double rows of legumes. Late planting can lead to reduced yields. Germination will occur within 5-7 days after sowing.

Weeding. It is an essential operation that eliminates competition from other non-desired plants. Weeding should therefore be done within 2-3 weeks after emergence. The second weeding depends on the rainfall and weed density.

Thinning and Roguing. Thinning is done three weeks after emergence and the first thinning when the soil has sufficient moisture to minimise roots disturbance and shock. Leave 2-3 plants per hole. Diseased plants should be removed to avoid further spread. This process is called roguing.

Crop Rotation. Crop rotation is highly recommended to reduce build-up of sorghum diseases and insect pests. Avoid rotating sorghum with the members from the same family like maize and millet.

Soil Nutrition Management. To achieve maximum production, the crop should be supplied with enough nutrients. The amount of fertiliser to be applied to the crop however depends on the fertility of the soil. Application of both basal and foliar fertilisers is recommended. At planting apply one bag (50 kg) per acre of compound fertiliser NPK (20:20:0, 23:23:0 or 17: 17:17). Top dress with one bag (50 kg) of

calcium ammonium nitrate (CAN) per acre preferably after first weeding. Application is done by drilling the fertiliser along the planting furrows and thoroughly mixed with the soil before planting and covering the seed. Manure improves soil organic matter which impacts positively on soil moisture retention and structure. Broadcast well-decomposed manure in the field close to the onset of the rains at a rate of 2 tons per acre and mix it with the soil during ploughing. Manure can also be spread in bands along the planting furrows and mixed with the soil before seeds are sown.

Pests and disease management

Integrated pest and disease management is recommended. Important pests and disease for sorghum and their management are summarised in the Tables 2.3 and 2.4.

Table 2.3.Sorghum pests and control options

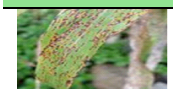
Pest	Signs and symptoms	Management
Shoot fly 	The yellowish or white maggots bores into the hearts of the shoot causing drying of the central growing shoot (dead heart)	Early uniform planting Spray with systemic insecticide like Atari, Seed dress with systemic insecticide such as Bell amid 600 FS at 3g/1 kg seed
Stalk borers	Caterpillar feed inside the stalks causing a stunted plant growth, windowing of leaves, withered shoots and often and poorly developed heads	Plant early into the season Field sanitation Apply insecticide into the funnels such as Bullock, Dipteral, Thiodan Practice Push Pull technology by intercropping with desmodium and napier round the edge of the farm
Birds 	Birds are one of the most important pests of sorghum. They are capable of causing heavy losses. The most notorious species is Quelea	Use bird scaring device Destroy their roosting sites Avoid isolated fields Timely harvesting

Source:KALRO sorghum manual

Table 2.4. Important diseases and their control options

Disease	Control options	Management
Anthracnose 	Anthracnose damages foliage and stems of grain sorghum. Dry lesions appear on the leaf surface. A brown sunken area with distinct margins develops appears on the stem holding the head (peduncle). When infected stems are cut lengthwise they have brick-red discolorations. The infection inhibits the flow of water and nutrients to the grain causing poor development.	Plant resistant/tolerant varieties Rotate with non-cereals Preferably with pulses. • Good management of crop residues.
Leaf blight 	Small reddish-purple or yellowish-brown spots on the leaves. Severely affected plants look as if they have been burnt. Under warm, humid conditions the disease may cause serious damage by killing all leaves before plants have matured.	• Plant resistant varieties • Use certified disease-free seeds. • Good management of crop residues.
Leaf rust	Small raised pustules or blisters on both the upper and lower leaf surfaces that rupture and release many reddish-brown spores. Appears when plants are nearly	• Use resistant varieties such as KARI Mtama 1

Table 2.4. Important diseases and their control options

	flowering. Forage yields are affected most. Grain yield losses are usually not serious.	• Rotate with non-cereals • Control weeds
Long smut 	The spores are seed borne and germinate soon after the seed is planted and invades the young sorghum plant. It continues to grow unobserved until heading stage, when the long pointed smut galls appear in the heads in place of normal grains. Unlike covered smut, this disease stunts the infected plants and often induces abundant side branches.	• Certified disease-free seeds Control weeds. • Rotation with non-cereals Field sanitation.
Smut 	Black masses of powdery spores instead of grains; the entire head becomes black. Plants become infected while in the seedling stage but infection is not apparent until the heading stage. The smut gall produces thousands of spores, which become soil-borne and initiate systemic infection of seedlings in subsequent years.	Plant resistant hybrids to avoid losses. Use certified disease-free seed. Rotate with non-cereals. Plough deep.
Ergot 	Dark brown to black sclerotia develop in place of seeds on the panicle. The spores are carried by insects or splashed by rain to infect flowers, where they invade the young kernels and replace them with fungal growth. The spores are also seed borne and soil borne but the damage becomes apparent when they reach the flowering stage.	Plant resistant varieties, Remove affected panicles. Plant clean seeds. Plough deep. Rotate with non-cereals Good field sanitation

Maturity, harvesting and storage

Sorghum is ready for harvesting 3-4 months after sowing, depending on the variety and ecological factors. This is when the grains are about 28-35 moisture content and do not produce milk when crushed. The heads are cut off with a knife or sickle and sun dried. Alternatively, the entire plant can be cut and the heads removed later. For large scale farming, combine harvesters are used. If the crop is meant for seed production, harvesting should be done at maturity stage while that meant for fodder should be cut when still green and fresh. Grains are obtained through threshing the dry heads, winnowing and may be seed-dressed for a longer shelf life. They are stored in treated gunny or PICS on pallets, not directly on the floor.

Pearl millet (*Pennisetum glaucum* L.)

Pearl millet head (Source: ICRISAT)

Pearl millet is an annual grass in the family Poaceae. Millets are a group of cereals grown in semi-arid regions, capable of withstanding high temperatures and can also escape drought. The grain can be used for food or for brewing and the straws as animal feed.

Ecological requirements

Pearl millet is very adaptable to a wide range of environmental and climatic conditions. It thrives at higher elevations compared to other tropical cereals and tolerates salinity better than most cereals. It grows best in an environment with medium rainfall, about 200-900 mm, an annual temperature range of 15-30 °C and in fertile, well-draining sandy loam soil with a pH between 5-8.5. The crop performs well in an altitude range of 500-2400 m. Areas with low rainfall and low relative humidity during seed ripening and maturation are best for regeneration.

Varieties

- **KAT/PM-1**- This is a grey seeded variety that matures between 2-3 months and yields between 8-10 (90 kg) bags per acre
- **KAT/PM-2** - A grey seeded variety that matures in 2 months and yield about 7 (90 kg) bags per acre
- **KAT/PM-3** - A grey seeded variety that matures between 2-3 months and yields 8-12 (90 kg) bags per Acre
- **Katumani** - Alt 250-1150, it is a red seeded variety, short and is drought tolerant. It takes 3 months to mature, production 630-900 kg per acre

Agronomic practices

Land Preparation. Pearl millet is a small seeded crop and therefore requires a fine seedbed for good seed germination and seedling establishment. A tractor or oxen plough can be used to open the field, harrow to break the large soil boulders. When hand-hoes are used for land preparation, the large soil boulders should be reduced by breaking them to provide a moderately smooth seed bed. Select fields not far from homesteads and avoid bird breeding sites.

Planting. Sowing is usually done by broadcasting or planting the seeds in furrows. The seedbed should be thoroughly prepared to a fine tilth because the seeds are very tiny. Seeds are sown to a depth of 2.5 cm allowing 25 cm between rows and 10-12 cm between plants. Finger millet should be planted as early as possible in the season on the onset of rains. The earlier it is sown the higher the yields. The crop can be planted as a pure stand or intercropped with other crops like beans, and cowpeas, among others. Germination occurs within a week after sowing.

Soil Fertility Management. During planting, it is recommended to apply NPK (20:20:0 or 23:23:0) at a rate of one bag (50 kgs) per acre. In soils with low fertility and in instances where rainfall continues beyond 30 days after planting, topdress with CAN at a rate of one bag (50 kg) per acre. Apply fertiliser along the furrows and thoroughly mix with soil before placing the seeds.

One can also apply manure to improve nutrients, structure and increase moisture retention capacity level in the soil. Only use well-decomposed manure by broadcasting in the field close to the onset of the rains and mix with the soil during ploughing. In case of low volumes of manure, it can be spread in bands along the planting furrows and mixed with the soil

before seeds are placed. Application of farmyard manure at 5 tons acre is recommended.

Weeding and thinning

- The first weeding should be done within 2-3 weeks after emergence and the second weeding is recommended depending on the weed density. Chemical weeding can also be done using pre-emergence herbicides.
- Thinning should be done when the soil is moist to ensure minimal disturbance of the roots of the remaining plants for a healthy growth. Thinning should be done 3 weeks after emergence (at 3- 4 th leaf stage and leave 1 plant per hole. This is best done after first weeding in order to accommodate appropriate plant density adjustments, and leaving two plants adjacent to it compensates for a gap within the row.
- Uproot plants that display abnormal characteristics like being taller than other plants, if the flower colour deviates from the majority of other plants, or grain colour that is different from that of the majority of plants.

Pests

Cutworms (*Agrotis spp)***:** These are black or brown in colour and cut off young plants at or slightly below the soil level. The attacked plants may eventually die.

Chafer grubs (*Amphimallon Majale)***:** These are whitish C-shaped caterpillars found in the soil which feed on the roots and may kill young seedlings.

Stem borer (*Coniesta ignefosalis)***:** The larvae/maggots feed on the funnels of the crop before tunnelling down to feed on the developing tissues. Others bore holes straight into the centre of the stem. Feeding causes stunted growth and production of sterile or poorly developed ear heads. In severe cases, the plant dies. Young plants are more susceptible to attack by stem borers

Shoot fly (*Atherigona Approximata)***:** The larva enters the funnel of the crop and moves down to feed on the young shoot, killing the growing point and the youngest leaf which turns brownish and withers. This damage is commonly referred to as ‘dead heart’. Tillers can also be attacked.

Midge (*Stenodiplosis Sorghicola)***:** The larvae feed on the developing grains causing them to shrink and flatten. Damaged panicles have small, transparent midge pupa attached to the tips of the damaged spikelets.

Armyworms (*S. Frugiperda)***:** These are seriously destructive pests which cause serious damage to mostly the young plants by eating away the leaves. Heavy infestations can cause defoliation.

Aphids (*Rhopalosipum maidis m sacchari)***:** They suck plant sap on the ear heads or on the undersides of the leaves and produce honeydew which encourages development of sooty mould. Infested plants become stunted, leaves dry up and yield is considerably reduced.

Earhead bugs (*Helicoverpa armigera)***:** The adults and nymphs feed on the developing kernels by sucking the juice from within the grains when they are in the milky stage. Kernels shrivel, become small and discoloured, especially if attacked in early development stages.

Diseases

Damping off (*Pythium* Spp*)***:** Infection causes rotting of seeds before they emerge as well as seedlings after emergence from the soil.

Cercospora leaf spot (*Cercospora penniseti)*: Small dark lesions develop on leaves which are usually oval in shape but may be oblong to rectangular. The centres of the lesions are grey to tan in colour with visible black dots and may be covered in spores during wet weather. These lesions may also be present on the stems and are slightly longer than those on the leaves.

Blast (*Pyricularia Setariae)*: Elliptical or diamond shaped lesions form on leaves. The centres of these lesions are grey and water-soaked, surrounded by chlorotic halo and there is an appearance of concentric rings on leaves

Rust (*Puccinia subtriata)*: Small yellow or white raised spots develop on the upper and lower leaf surfaces. These spots tend to be more numerous on lower leaf surfaces. They enlarge and develop into red-brown pustules which may be surrounded by a yellow halo.

Downy mildew (*Sclerospora gramincola)*: The infected plants develop thick, stiff, twisted, pale green leaves with bumpy surfaces. In severe cases of infection, the plants do not produce.

Maturity, harvest and postharvest handling

Pearl millet is usually ready to harvest between 2.5 and 5 months after sowing depending on the variety. The crop is usually harvested manually by cutting the heads with knives at physiological maturity and sun-dried before threshing and drying to 12-13% MC. For large scale farming, combine harvesters are used to cut off the head or the whole plant.

Threshing and sorting of the dry grain can be dusted with Actellic or Actellic for protection against storage pests. If the grain is meant for seed, then it should be dressed with Bellamid 600 FS or Gaucho FS 350 for protection against soil pests.

The grain should be kept in either metal or plastic containers. When sisal bags are used, they should be kept in a cool, dry and well-ventilated place. If grain is kept for more than 90 days especially in hot areas, a second dusting is recommended after 3 months.

Furher reading

Esilaba, A.O., Nyongesa, D., Okoti, M., Otipa, M. and Lusike Wasilwa. (2021). KCEP-CRAL Millet Extension Manual. Kenya Agricultural and Livestock Research Organisation, Nairobi, Kenya.

Pigeon peas (*Cajanus cajan*)

Pigeonpea crop (Photo: KALRO Pigeon pea extension manual)

Pigeon pea is a legume crop that belongs to the family Fabaceae. It is commonly cultivated in the semi-arid tropics. In Kenya, pigeon pea is the third most widely grown pulse crop. Besides other regions, pigeon pea is largely cultivated in the Eastern and Coastal regions of Kenya in large pieces of land. Both the green and the dry pulses are consumed locally or exported to other countries like Tanzania, Malawi etc. Pigeon peas can be eaten as vegetables (immature pods or the green pigeon pea) or as dried grains. The crop can be intercropped with other crops like maize, sorghum, cowpeas, beans, cassava, etc.

Varieties

Pigeon pea varieties vary in form of seed, taste, colour, growth habits, flowering time, susceptibility to pathogens, among other traits. The following are some of the most commonly cultivated pigeon pea varieties;

- Mbaazi -1, 2 and 3
- Kat 60/8, 81/3/3and 777
- ICPL 89091
- Local Races
- More varieties can be accessed through: : https://kalro.org/kcsap/index.php/resource-centre/pricing-table/latest items

Ecological Requirements

- Temperature: Pigeon pea does well in a temperature range of between 18-38 ^{o}C. The plant cannot withstand frost.
- Rainfall: An annual rainfall range of 600-1000 mm is adequate for the cultivation of this crop. It however flowers well where the rainfall is between 1500-2000 mm. Excessive rainfall during flowering causes flower abortion and increased disease incidences. Dry weather conditions are needed during harvesting
- Soil: The crop thrives in a well-drained soil with an optimal PH of 5-7. It is very sensitive to high salinity and does not tolerate shallow and water logged soils.

Agronomic practices

Planting. Pigeon pea is propagated by seed. Seeds should be certified and disease free. Damaged or shrivelled seeds should not be planted. Before planting, land should be prepared to a fine tilth. Seeds are directly planted in 53 a deep ploughed garden, at a spacing of 35-50 x 75-150 cm, and a depth of about 10 cm. However, this spacing depends on the various varieties, soil type, production system of the variety, etc., For instance, in drier regions, a wider spacing is adopted in order to reduce competition for nutrients and water. Planting should be done at the onset of the rains if production is rain fed. Delayed sowing may cause crop failure or reduced yield. Germination takes place within 5-7 days and this depends on the variety and environmental factors. Pigeon peas can be grown as a pure stand or intercropped. When intercropped, spacing is more than when monocropped.

Soil Fertility Management. It is always important to ensure that plants are supplied with sufficient amounts of nutrients. This enables them to carry out their normal activities successfully leading to considerably increased yields. Plants that have been deprived of nutrients are highly susceptible to attack by pathogens and this affects overall yield directly.

During planting, a mixture of manure and DAP is recommended. In order to enhance efficient nutrient uptake by the young plants as well as stimulating their growth, mix 1

kg HUMIPOWER with one ton manure or 50 kg basal fertiliser. 4-5 weeks after germination, it is advisable that top dressing is done. Normally CAN is used, which should also be mixed with HUMIPOWER. However, these basal fertilisers need to be supplemented with foliar fertilisers because they have a wide range of nutrient elements which are very vital to the plants.

Weed Control. Weeds compete with the crop for nutrients, water, space and light. They should thus be controlled in order to facilitate proper growth and development of the crop. During land preparation, spray weeds with CLAMPDOWN 480SL 200 ml/20l. This helps get rid of all types of weeds, leaving the garden weed free.

Pests

Aphids (*Aphis craccirora*): These are soft bodied insects, usually green, black or brown which suck plant sap. Infested leaves curl and crinkle. They also attack the pods. As they feed, they excrete honeydew which facilitates the development of sooty mould which reduces photosynthetic area. Stunted growth is noted

Pod sucking bugs (*Nanaguna breviuscula*): These suck the developing seeds through the wall of the pod causing the seeds to become shrivelled with dark patches. The damaged seeds are not recommended for food and cannot germinate as well. These bugs include; spiny brown bug, giant coreid bug, green stink bug etc

Red spider mites (*Oligonyclus gossypii*): These feed by piercing and sucking the plant sap. They feed on the underside of the leaf leading to formation of whitish or yellowish patches. Heavy infestations can cause defoliation. These pests form webs on the lower sides of the leaves.

Cutworms (*Agrotis* Spp): They cut the stem of younger plants below the soil surface. The infested plants wither eventually.

Scales (*Hemiptera* Spp): These appear as small shells glued to the plant and suck sap on any above ground part of the plant. Infested leaves turn yellow and may drop and diebacks of infested branches result. As they feed, they secrete honeydew which facilitates development of sooty mould

Pod borer (*Nanaguna* Spp): The most common one is the African bollworm. These pod borers feed on leaves, flowers and pods thus damaging them. They bore holes on pods and feed on the seeds

Pod fly (*Malansgromyza obtusa*): This is a small black fly that lays eggs on the pods which hatch into white maggots. These maggots feed on the green seed and later form into brown barrel shaped pupae. The damaged seeds are of no value. They also feed on leaflets and flowers making small holes in them

Pod weevil (*Apion rostrum*): The adult is a small black beetle. The larvae are creamish white and they feed on the green seeds. However, damage is only noticed as the adult comes out of the pod

Whiteflies (*Bemisia tabaci*): Are white insects which suck plant sap. Infested leaves curl, become distorted and eventually drop. They also secrete honeydew as they feed which enhances the development of sooty mould on the leaves affecting photosynthesis

Thrips (*Thysanoptera* spp): These feed on leaves and flowers by sucking the sap. Heavy infestations cause flower and flower buds abortion. Leaves also may fall off

Leaf miners (*Agromyzidae* Spp): The larva mines under the leaf surface, resulting in formation of mines / winding trails which increase in width as the larvae mature. This reduces photosynthetic area leading to leaf withering

Root knot nematode (*Meloidogyne* Spp): The major characteristic symptom is the development of swellings/galls in the roots which rot as infestation progresses. The infested plant is usually stunted and eventually wilts and dies

Whenever applying basal fertilisers, mix 50 kg fertiliser e.g. DAP, NPK etc. with 2 kg ADVENTURE. This helps to control nematodes.

Diseases

Cercospora Leaf Spot (*Cercospora* Spp): Infection leads to development of small light brown lesions on the upper surfaces of the leaves. In severe cases of infection, leaves die.
Fusarium Wilt (*Fusarium Oxyspiorum*): Attacked plants show sudden yellowing of leaves which eventually fall off, making the plant to wither. There's usually some blackened tissue at the base of the stem. These symptoms can also be found on one side of the plant.
Powdery Mildew (*Erysiph* Spp): Plant parts are covered with whitish fungal growth. Heavy infestations cause defoliation.
Rust (*Puccinia triticina eriks*): Lower leaf surface develops dark brown raised pustules which have the fungal growth. As infection progresses, leaves desiccate and fall off. Defoliation occurs in severe cases.

Harvesting and storage

Depending on the variety, pigeon peas can be harvested 4-8 months after planting. They may be harvested while green or when dry and mature pods are picked individually. When most of the pods are mature, the plant can be cut at its base, near the ground. However, this method is rarely practised.

Dry pigeon pea seeds are stored in treated gunny or PICS bags which help to prevent major damages caused by storage pests like brucchids. It is advisable to incorporate the seeds with an insecticide, e.g. Actellic super to prevent pest damage during storage.

Bags should be placed on pallets, not directly on the floor. These can stay up to about 8 months while still in good condition. Once harvested, the green pigeon peas are peeled and cooked. They can also be refrigerated for about 7-10 days. Pigeon peas are rich in vitamins and other nutritional elements. They can be cooked alone to be served with a wide range of foods e.g. rice, or mixed with different grains like maize.

Green gram/mung bean (*Vigna radiata*)

Green gram crop (Photo: KALRO green gram extension manual)

Green gram/Mung bean (*Vigna radiata*) also known as Mung beans and in Kiswahili Ndengu, belonging to the Fabaceae family is an annual leguminous crop which is grown for its seeds, with high nutritional content. They are well suited to diverse environments and fit in various cropping systems, low input requirements, fast growth, nitrogen fixing and weed smothering ability. They are commonly grown in central, South Nyanza, eastern and coastal regions. Its edible grain is characterised by good digestibility, flavour, high and easily digestible protein content and absence of any flatulence effects. It's also a crucial source of vitamins A and B, micronutrients such as iron and zinc which are essential for pregnant women and children.

The crop is easy to cultivate and can grow up to a height of 30-120 cm, producing pods. Dried seeds are cooked or milled into flour, while the crop residues are used as fodder or in making green manure.

Ecological requirements

Green grams thrive in a well-drained soil preferably sandy loamy soil, rich in nutrients and with an optimum PH of 6.0-7.5. It grows best at an altitude of 0-1600 m with an optimum temperature of between 25-30^{o}C. It is relatively drought tolerant and can give reasonable yields with an annual rainfall of between 350-700 mm. Too much rain or long dry spells reduce yields. Excessive rainfall during flowering causes flower abortion while dry weather conditions are important during harvesting.

Varieties

There are two major varieties that can be differentiated through the grain colour. These are the yellow and the green grain grams. The N26 green gram variety is small and ripens unevenly while the improved variety KS20 has bigger seeds and tends to ripen uniformly

- KS20 (uncle: Matures in 80-90 days, pods turn brown when dry while grains are dull green in colour and bigger in size compared to N26
- N26 (nylon): Matures in 60-65 days, pods are black when dry and grains are shiny green in colour
- Karembo: Ndegu tosha and Biashara are the recent introduce by KALRO and marketed by KALRO seed unit
- They are large seeded varieties, early maturing, uniformity in ripening and, do well in dry areas
- Karembo: Matures in 75 days, yield 8-9, 90kg bags per acre
- More varieties of different crops can be accessed through; https://kalro.org/kcsap/index.php/resource-centre/ pricing-table/latest-items

Agronomic practices

Land Preparation. To realise high yields, select highly productive land suitable. Always avoid steeply sloping land, land which is near a swamp, very sandy soil and areas with shallow surface soil and a lot of couch grass. Land preparation should be done early enough so that the field is free of weeds and ready for planting at the onset of rains. Seed bed should have fine soils. A level seedbed facilitates planting to a uniform depth and uniform distribution of water

Soil Fertility Management. It is advisable to use fertilisers on the basis of soil test and recommendations, a basal dose of NPK (23:23:0) 1 bag (50 kgs)/ acre may be

broadcasted. Nitrogen fertiliser is usually not applied as green grams fix their own nitrogen, but 10-20 tons (100-wheel barrows) per acre farm yard manure can be applied. The manure should be broadcasted just before rains start and ploughed in. Fertiliser should be well mixed with the soil before placing the seed. Lime should be applied one year prior to growing green grams and thoroughly incorporated

Planting. Land should be prepared to a fine tilth before planting. Propagation is by seeds. The seeds should be certified or disease free. Damaged or shrivelled seeds should not be planted because they will not germinate or establish well. Seeds are planted at a spacing of 45*15 cm, a depth of about 3-5 cm. An acre needs 4-6 kg of green gram seeds. Planting should be done at the onset of the rains if production is rain fed. Delayed sowing may cause crop failure or reduced yield. Germination occurs within 5-7 days and this depends on the variety and environmental factors. Green grams can be planted alone or intercropped with other crops like maize, sorghum, cowpeas, etc.

Weeding. Weed control in green grams is essential, to reduce competition for nutrients which result in low yields. Weed-free crop of green grams decreases insect pest infestation. The most common weeding method is hand weeding but oxen can be used too. The first weeding should be done 2 weeks after emergence and the second before flowering

Crop Rotation. Green grams in a mono cropping system should be rotated with non-leguminous crops such as maize, millet, sorghum, sweet potatoes and cassava. This practice is recommended to avoid pest and disease build up. It is not advisable to grow mung beans for two consecutive seasons on the same field. Mung beans leave a nitrogen- rich soil allowing subsequent crops to benefit and grow successfully. Losses of up to 10-45% in green grams have been associated with common blight while 80% due to angular leaf spot disease. Therefore, pests and disease management is very important for high grain yield and quality.

Pests Cutworms (*Lepidoptera* Spp): These are brown or black caterpillars usually found in the soil, which cut the stem of younger plants below the soil surface. Heavy infestations can lead to total crop loss

Aphids (*Aphis craccivora*): These are soft bodied, green or black insect pests which suck plant sap. Infested leaves curl and crinkle and attack the pods as well. Aphids excrete honeydew as they feed, which encourages the development of sooty mould

Pods Sucking Bugs (*Nanaguna Spp*): These include giant coreid bug, green stink bug, etc. they suck sap from the pods and seeds. This may cause necrosis, pod malformation, premature drying, formation of empty pods, shrivelling of seeds, among others

Pod Borers (*Nanaguna Spp*): These include the African bollworm and they feed on leaves, flowers and pods. They bore holes on pods and feed on the seeds, with the heads inside the pods. These borers cause significant losses if not controlled

Whiteflies (*Benusia* Spp): These are white flying insect pests which suck plant sap and secrete honeydew as they feed which facilitates the development of sooty mould. Infested leaves curl, become distorted and eventually drop. They are also vectors of plant diseases

Foliage Beetles (*Ootheca* Spp): These feed on the leaves leading to defoliation, especially of the young plants

Thrips (*Thysinoptera* Spp): These prefer mostly the flowers, although they also feed on leaves and petioles. Attacked flowers turn brown, dry and become distorted. This decreases pollination ability and seed set

Bean Flies (*Ophiomyia phaseoli*): The larvae (small whitish maggots) tunnel through the main stem and feed, causing significant damages. In severe cases of infestations, Seedling may die, leaves of the older plants turn yellow and become stunted while stems get thicker than normal and crooked

Diseases Damping off (*Rhizoctonia* Spp): Infection causes rotting of seeds before they emerge as well as seedlings after emergence from the soil

Anthracnose (*Colletotrichum lindemuthianum*): This attacks all the above ground parts of the crop but pods are mostly damaged, whereby they develop brown sunken lesions. These lesions are covered with pink spores under humid conditions. The seeds become brownish black

Powdery Mildew (*Erysiph* Spp): Infection causes development of white powdery patches on the leaves and other plant parts which gradually enlarge, covering the entire surface, as infection progresses. Severely infected parts turn yellow and are distorted, defoliation occurs

Bacterial Blight (*Xanthomonas axonopodis* pv *vignicola*): Infection causes formation of small brown blotches on the leaves which enlarge as infection continues, eventually causing the leaves to fall off and subsequent death of the plant

Rust (*Puccinin* Spp): On infection, the disease appears as reddish-brown blisters which are found mainly on the underside of the leaves, on pods and stems. In severe cases, both sides of the leaves are covered with rust pustules and defoliation may follow, while pods shrivel

Yellow Mosaic (*Comovirus*): This is a viral disease which causes serious losses. It is transmitted by whiteflies. Infected leaves become necrotic, diseased plants are stunted, mature late and produce few flowers and pods. The pods are usually reduced in size and turn yellow

Control vectors (whiteflies) by spraying TAURUS 500SP 10 g/20l or PROFILE 440EC 30 ml/20l. Green grams mature within 60-90 days after sowing, depending on environmental factors as well as the variety.

Harvesting and storage

Harvesting should be done when most of the pods have turned black. This is achieved through picking the individual pods or uprooting the entire plant. Delayed harvesting results into shattering of the pods and other losses can occur, e.g. infestation by pests. The harvested pods should be dried for 2-3 days then threshed and winnowed, ready for consumption or storage.

Green grams are very susceptible to attack by brucchids and should therefore be stored soon after sun drying in airtight containers or gunny bags in a clean ventilated room. Seed treatment is recommended for a longer storage period.Note that proper drying of the green grams is highly required in order to prevent contamination with aflatoxins and development of pathogens. Infected seeds should not be mixed with the sound ones.

Further reading

Esilaba, A.O. *et al*. (2021). KCEP-CRAL Green Gram Extension Manual. Kenya Agricultural and Livestock Research Organization, Nairobi, Kenya

Cowpeas (*Vigna unguiculata*)

Cowpea seeds and crop (Photo: KALRO cowpea extension manual)

Cowpeas belong to the family Papilionaceae. The crop is of major importance to the livelihoods of local communities people in developing countries. In Africa It is an important agricultural crop because it is source of nutritious food, high quality of animals feed, importance in cropping system, replenishing degraded soils, suppression of weeds, drought tolerant, used as both grains and leaves and source of income. Ecological Requirement Cowpea is adapted to high temperatures ranging between 20-35° C. It does not withstand floods. The crop is fairly tolerant to drought. It requires a rainfall range of 600-1100 mm per annum. Excessive rains lead to delayed ripening and reduced grain yield (Table 2.5). It grows well in a wide range of soil from heavy clay to varying proportions of sand and clay. Cowpeas thrive best in the pH range of 5.5-8.5. The crop can tolerate salinity to some extent but can withstand soils with high aluminium.

Varieties

Table 2.5. Cowpea varieties with different traits

Variety	Maturity in days	Yield potential in 90 kg bag/acre	Traits
Machakos 66 (M66)	80-95	3.5-7.5	Dual purpose erect variety, smooth creamy brown seeds with small eye and tolerant to yellow mosaic virus and scab
Kunde- Tumaini	70-80	6.6-9.4	Deep brown large sized grain, early maturing, semi erect and dual-purpose variety
Kunde- Tamu	70-80	2.5-8.8	Tender and sweet leaves when cooked, brown greenish ring around the helium, semi-erect and dual-purpose variety
KAT- Kunde	80-90	6.2-8.8	Creamy brown grain, semi-erect and dual-purpose variety
Katumani 80 (K80)	75-85	3.5-8	Dual purpose, semi spreading habit, smooth and creamy brown with a small eye grain, resistant to aphids, tolerant to pests and resistant to foliar fungal disease and mosaic virus

Table 2.5. Cowpea varieties with different traits

Kunde- Soko	80-90	6.2-8.4	Brown Large to medium sized grain, Eye pattern is brown greenish and Semi- erect Variety
KVU-419	65-72	4.4-6.6	Grown for grain rather than leaves. smaller grains than both M66 and K80. Tolerance to cold and recovers very fast from drought
KVU 27-1	70-90	3.5-8	Dual purpose,semi spreading habit, Grains are dark red in colour. Moderately tolerant to pests and resistant to foliar fungal disease and mosaic virus
KVU HB 48E10	85-95	4.8-6.6	More vegetable type than grain type
Kunde 1	75-90	5.3-11	Dual purpose
KCP 022	60-75	11	Drought tolerant
MTW 63	60	11	Pest tolerant
MTW 610	60	9	Large grains
ICV	75	7	Pest tolerant

For seed multiplication conduct KALRO and KEPHIS

Agronomic practices

Land Preparation. Land should be prepared early enough so that the field is free of weeds and ready for planting at the onset of rains. The land should be prepared to a fine tilth and levelled so as to enhance moisture absorption and retention, easy germination and root penetration, ensures better surface contact between the seed and the soil and for uniform depth

Planting. Cowpeas is planted by direct seeding at a spacing of 60 × 20 cm and 50 x 75 cm, depending on the variety. Seeds should be planted at the onset of rains. For a good plant stand and high yields, seeds must be of high quality. For early maturing varieties, planting at the beginning of the rains is advised so that the sensitive stages of the crop avoid the peak activity of insect pests. Ideally, planting should be timely in relation to the maturity period of the variety, such that the crop is harvested during the dry weather

Fertiliser Requirement. The cowpea is a legume that fixes its own nitrogen. Too much fertiliser will result in heavy vegetative growth and reduce grain production. Use of at least 2 tons/acre of well- decomposed compost or farmyard manure is recommended especially in areas where soils are low in organic matter content. This is best applied under dry conditions and then mixed with the topsoil, about one week prior to planting

Cowpea requires more phosphorus (P) than nitrogen. About 60 kg/acre of (P2 O5) is recommended for cowpea production to help the crop to nodulate well and fix its own nitrogen from the air. Phosphorus is critical to cowpea yield because it stimulates growth, initiates nodule formation as well as influences the efficiency of the rhizobium-legume symbiosis. The fertiliser should be thoroughly mixed with soil before placing the seed

Weed Control. Cowpea should be kept free from weeds in all stages of growth. Timely weeding is absolutely essential. Thorough weeding which reduces the risk of weed spreading and reduces the pest and disease infestation at the early stages is achieved by a first weeding two weeks after emergence followed by a second weeding three weeks later (just before flowering) in monocropping. In intercropping, one weeding three weeks after planting may be sufficient except in high rainfall areas where a second selective weeding three weeks later may be necessary. Care should be taken to avoid damaging the shallow roots especially during the first weeding. Cultivation during

flowering time is discouraged, to avoid flower shedding and when the field is wet to avoid spread of diseases and soil compaction

Pest and disease management

Pests (Table 2.6) and diseases (Table 2.7) contribute to reduction in crop yields. The severity varies because of changes in environmental conditions and management practices.

Table 2.6. Cowpea pests and management options

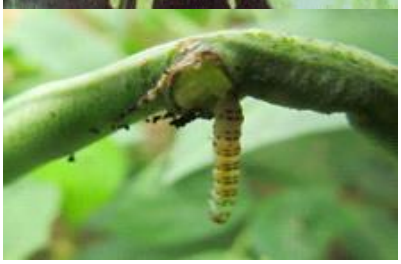
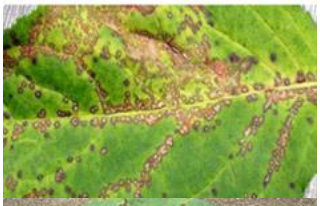
Pest	Damage symptom	Management
Armyworms (*Spodoptera exigua*)		Hand-picking, crushing or dipping in hot water, Use neem based biopesticides e.g nimbecidine at 50 ml/20 L of water and Spray insecticides e.g Lufenuron Emamectin Benzoate, Lufenuron, Lambda-cyhalothrin, Deltamethrin based insecticides.
Pod-borers		Handpick and destroy the caterpillars and Use bio-pesticides such as Bt or neem based products
Root-knot nematodes		Maintain high levels of organic matter using manure and compost in the soil, Incorporate neem cake powder into the soil, Rotate cowpea with other recommended cross, use biopesticides e.g nimbecidine at 50 ml/20 L of water and Use repellant crops such as marigold
Aphids (*Aphis craccivora*)		Plant early, Destroy and bury infested plant materials to reduce aphid colony in the field , Practice crop rotation, use of sticky traps (blue/yellow), and yellow water. Spray soapy solution and use overhead irrigation to knock aphids off the leaves.

Table 2.6. Cowpea pests and management options		
Red spider mites (*Tetranychus spp.*)		Avoid planting next to infested fields, Avoid frequent use of broad-spectrum pesticides, particularly pyrethroids as this may lead to spider mite outbreaks.
Whitefly (*Bemisia tabaci*)		Mount yellow sticky traps to trap adults, Spray with pepper, Conserve natural enemies and parasitoids Drench with imidacloprid based products and Spray lambda-cyhalothrin based products Spray alpha-cypermethrin based products

Integrated disease and pest management and the use 59 of environmentally safe strategies is recommended.

Table 2.7. Cowpea diseases and management options		
Disease	Damage symptoms	Management
Anthracnose *(Colletotrichum lindemuthianum)*		Use certified seed and practise crop rotation with non-legumes, Spray with Flutriafol 125/L based product
Bacterial Leaf Blight *(Xanthomonas phaseoli)*		Destroy infected plant residues and use disease-free seed, Use copper based products
Powdery Mildew *(Erysiphe polygoni)*		Practise early planting, crop rotation with non-legumes for 2-3 seasons Observe high field hygiene, uproot and destroy severely infected plants to reduce inoculum in the field, apply sulphur based protective fungicides

For more information on pests and disease management in cowpeas, open this link https://www.kalro.org/files/kcep/cow peas18-6-21.pdf

Harvesting and storage

Dry cowpea should be harvested when the plants turn yellow to light brown and the leaves start to fall off by hand picking the pods since they mature unevenly. Uproot the entire plant when it has reached full physiological maturity. Early-maturing and erect varieties, the pods mature and dry evenly, hence harvesting can be done once by uprooting the entire plant or hand picking. For indeterminate and prostrate varieties, the pods mature and dry unevenly

hence the pods should be hand-picked as they mature and dry. Harvesting should be prompt, as delay in harvesting encourages weevil infestation in the field and seed shattering. If the condition is humid the quality of grains may deteriorate due to mould.

Further reading

Esilaba, A.O., Nyongesa, D., Okoti, M., Otipa, M. and Lusike Wasilwa. (2021). KCEP-CRAL Cowpea Extension Manual. Kenya Agricultural and Livestock Research Organisation, Nairobi, Kenya.

Mango (*Mangifera indica* L.)

Commercial mango varieties of Kenya (Photo: Lusike Wasilwa)

Mango belongs to the family Anacardiaceae with 75 genera and 700 species. It is one of the high potential fruits in Kenya, suitable for different agro-ecological zones ranging from sub-humid to semi-arid. In 2016, this fruit was ranked 2nd in terms of value amongst fruits. Mango is produced for both local and export markets. The country has a huge potential to further increase mango production. However, the quality and quantity of fresh and processed mango cannot adequately meet the demand of both domestic and export markets. Profit of small-scale farmers, who are the main producers of mango, can however be improved by cultivating the most suitable varieties (Table 2.8) and applying better tree management practices such as integrated pest management (IPM). Ecological and Site Requirements Along the Coastal region of Kenya, mango undergoes two main growth flushes, one in May to June and another November to December each year. However, in medium altitude areas, (southern eastern regions), the main growth flush occurs in May to June after the long rains. These growth flushes are followed by flowering about 3 months later.

Table 2.8. Mango varieties

Cultivar	General attributes
Ngowe	Large and long in size, Excellent flesh and fibre-free, Deep yellow colour, Early season (Jan–Mar), Resistant to anthracnose and it is mainly for export. [Hot to low alt. area (0-700 m)]
Boribo	Long and large fruit size, Deep orange-red flesh and fibre-free, Early season (Jan – Mar), Resistant to anthracnose and mainly consumed locally. [Hot to low alt. area (0-700 m)]

Table 2.8. Mango varieties	
Apple	Medium and round sized fruit, Bright yellow – orange to red fruit colour when ripe, Excellent flavour, Early season (Dec–Mar), Resistant to anthracnose and mainly consumed locally. [Hot to low alt. area (0-700 m)]
Batawi	Very large and round sized fruit with green to purple maroon colour, flesh has good texture, little fibre and good flavour, late season (Mid Jan–Mar), Resistant to anthracnose and mainly consumed locally. [Hot to low alt. area (0-700 m)]
Tommy Atkins	Juicy red fruit, firm, very sweet and fibreless, tree full and dense Early season (Jan-Mar), Resistant to anthracnose [Low to mid alt. areas (500-1500 m]
Van Dyke	- Red fruit, orange-yellow flesh, with scanty fibre, oval shape,Mid-season (Jan-Mar) [Low to mid alt. areas (500-1500 m]
Kent	Green/red/yellow, soft, sweet and fibreless fruit, large and upright tree, late season (March-April), Resistant to anthracnose. [Low to mid alt. areas (500-1500 m]
Sabine	Elongated medium size fruit, Moderate-large tree, late season (January-March), Resistant to anthracnose. [Low to mid alt. areas (500-1500 m]
Keitt	Large fruit, heart shaped, Yellow flesh colour, Moderate size tree, late season (March-April), Resistant to anthracnose. [Low to mid alt. areas (500-1500 m]

Ecological and site requirements

Along the Coastal region of Kenya, mango undergoes two main growth flushes, one in May to June and another November to December each year. However, in medium altitude areas, the main growth flush occurs in May to June after the long rains. These growth flushes are followed by flowering about 3 months later.

Altitude	Temperature	Rainfall	Soil
0-1500	24-35	>650 mm pa	PH 5.5-7.5
		tolerant to drought	Deep well drained, loam or clay, Not too waterlogged, alkaline or shallow constant supply of nitrogen

Establishment of a Mango Orchard

The following considerations must be put in place

- Choice of the proper location and suitable variety
- Arrangement of the orchard; pure stand or where soil is not fertile adopt the spacing of 10 by 10 m, grafted tree is spaced at 8 by 10 m or 10 by 12 m. Mango trees can be grown together with many other plants: as border trees on cultivated gardens, in intercropping within the gardens, in very diverse agroforestry systems or in silvi-pastoral systems (using small animals, such as sheep or goats)
- Planting and management of mango seedlings; Spacing of between 8-12 m2 (ideal situation) or 10*10m (dry zones) or 5*3 m or 5*2.5 m or 3*2.5 m or 2.5*2.5 m (where high-density planting is required). Prepare the planting holes 1 month before planting to allow for seasoning/withering. Depth of hole should be 1 x 1 x 1 m3 (in shallow and hilly soils) or 0.5*0.5*0.5 m (in loamy and deep soils) · Top soil should be separated from the subsoil when digging the holes
- Transplanting and fertiliser management. Mix topsoil with manure and fertiliser as follows: 1 debe of manure per hole (in the ratio of 1 debe manure to 3 debes of topsoil), About 60 g of a compound fertiliser (NPK) e.g. DAP, depending on the fertility of the soiland return the mixture to the hole filling to about 2/3 of the hole

Remove the polythene sleeve carefully so that the plant can be planted with the entire ball of the soil, Clip the longer roots to avoid bending during transplanting, Place each of the seedlings at the centre of the planting hole, Cover the seedling at exactly the same depth as it

was in the polythene sleeve leaving about 6 inches below the soil surface, Once the trees are established (about 3-6 months after Planting), start applying nitrogenous fertilisers e.g. CAN as follows:- 1st year 50 g CAN/tree, 2nd year 100 g CAN/ tree, 3rd year 150 g CAN/tree and 4th year 200 g CAN/tree. Mulch the base of the transplanted seedling to conserve moisture. Water must be supplied on need basis.

Nitrogen fertilisers should be applied in splits to avoid leaching out.

Pruning. The form and height of a mango tree need to be controlled to guide the tree and to facilitate harvesting at a later stage There are two main forms of mango pruning; Formative pruning (It is done in the first years of the young tree to guide the tree into the desired shape) and Structural pruning (should be done for proper maintenance of the trees and should be done mostly after fruit harvest)

- Improving flowering and fruit formation
- Pegging heavy branches; done on heavily loaded varieties or trees to avoid breaking

Weeding. Remove weeds regularly beneath the mango tree, so as to minimize competition and harbouring "PESTS". This can be done by using chemical, biological, physical or manual methods.

- Chemical method: Control weeds in mango orchards by applying herbicide like paraquat (3.0 kg a.i/ha), Diuron as pre-emergent treatment at 6.67 and 8.9 kg/ha. Bromacil and dalapon are herbicides for controlling dicot and monocot weeds respectively
- Biological control. A common practice of grazing livestock in a well grown and established orchard
- Physical Method involves the use of plastic mulch, uprooting or use of hand hoe

Table 2.9. Mango pests and management options

Pest	Appearance/Damage	Management
Fruit fly (*Bactrocera invadens*)		Collect and destroy all fallen fruits at least twice a week during the fruit season, pick overripe fruits as they attract fruit flies, use of physical method like traps and fruit bagging
Mango seed weevil (*Sternochetus mangiferae*)		Keep the orchard clean, apply sticky bands at the upper end of the trunk just before branches, Regular scouting and remove fruits with egg laying marks and destroy them.

Table 2.9. Mango pests and management options

Mealy bugs (*Rastococcus Spp*)		Destroy affected parts at the beginning of the infestation, Conserve natural enemies, avoid excessive spraying and the use of broad-spectrum pesticides since they may kill natural enemies, control ants tending mealybugs

Table 2.10. Mango diseases and management options

Disease	Damage sign	Management
Powdery Mildew (*Oidium mangiferae*)		Consider planting appropriate cultivars, weekly monitoring of the disease, spray solutions of baking powder, white oil and white bar soap foam, apply Sulphur based fungicide
Anthracnose(Colletotrichum gloeosporioides)		Plant tolerant varieties, cut out dead branches, twigs and leaves, weekly monitoring of the disease
Bacterial spot(*Xanthomonas campestris*)		Use appropriate cultivars for specific region, prune off diseased twigs, establish windbreaks around the orchard, spray with copper-based chemical, monitor for the disease weekly
Scab (*Elsinoe mangiferae*)		Use of cultural practices, genetic plant resistance, certified seeds and chemical control (copper based)

Maturity indices and post-harvest handling links for fruits:https://horticulture.agricultureauthority.go.ke https://www.fao.org

Harvesting

A mango plantation is ready for harvesting in 1-6 years after transplanting, depending on the variety, management and the planting material used. Good production is realised after eight years for the non-grafted and reaches full maturity at 20 years of age. One tree should produce 200-500 fruits per year and varieties like “Dodo” and “Boribo’’ can produce 1000

fruits per year. Depending on cultivars and environmental conditions, Kenyan mango varieties take 90 to 160 days after flowering to reach maturity. The fruit will have its best flavour if allowed to ripen on the tree. The fruits are generally picked when they begin to change colour. Harvesting is done by hand-picking mature fruits or clipping them off with a long stalk of about 2-3 cm and packing the fruit in a single layer with the stalks facing downwards in the box or crate. It is important that the latex dripping from the stalk drops onto an absorbent material.

Further reading

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Katama, C.K. and Pole, F.N. (2010). Make money from mango products: Mango juice. Wasilwa, L.A., Muinga, R.W. and Rege, R.A. (eds). Kenya Agricultural Research Institute, Mtwapa, Kenya

Kehlenbeck, K., Rohde, E., Njuguna, J.K., Omari, F., Wasilwa L., Jamnadass, R. (2010). Mango cultivar diversity and its potential for improving mango productivity in Kenya. Horticulture Africa. horticulturalnews@gmail. com

Water melon (*Citrullus lanatus*)

Water melon crop (Photo: Farmbiz Africa)

Watermelon is a warm season crop that belongs to the cucurbit family (Cucurbitaceae). It is an indigenous popular fruit for fresh consumption and agro-processing, such as juice making that is native to the dry plains of tropical and subtropical Africa. The crop is one of the most widely cultivated crops in the world. Watermelon is a good cash crop with very good market opportunities, particularly in urban areas. The fruit has substantial amounts of food energy, carbohydrates, fats, protein and calcium. A watermelon fruit contains about 6% sugar and 92% water by weight. As with many other fruits, it is a source of Potassium, Vitamin A, Vitamin C, Folate and Amino acid.

Ecological requirements

Watermelon	Temperature	Rainfall	Soil	Altitude
	20-28	400-1000 mm pa	PH 6.0-6.8	0-1500
		Excessive humidity favour leaf diseases and affect flowering.	Slightly acid, well drained sandy loam	

Management practices of watermelon

Varieties

There are over 1200 varieties of watermelons worldwide and a wide variety of watermelons have been cultivated in Africa. Several of these varieties have been recommended for Kenya's climate. These include:

Sugar Baby. Round dark green to black fruit with deep red flesh, Very sweet and juicy, Matures after 120 days, Average fruit weight 4 kg and yield potential is 20-30 tons/acre.

Sukari F1. Early to medium maturing, Good fruit setting ability, Fruits are oblong in shape, Rind colour: light green with dark green stripes, Maturity Period is 90 days, Average fruit weight range between 7-8 kg, Yield Potential is 25-35 tons/acre and has good transport and keeping qualities.

Crimson Sweet. Has a light green rind with broad dark green stripes, has blocky oval shaped with brilliant red flesh, Maturity Period is 90-120 days, Average fruit weight is 7-9 kg, Yield potential 25-30 tons/acre and Good shipping quality and resistant to extreme heat and Root-knot Nematodes.

Sweet Rose F1. Vigorous with good adaptability, fruits are oval to round, good keeping quality, flesh is deep crimson red with good texture, maturity Period is within 80 – 90 days after transplanting and the average fruit weight is 10-12 kg.

Charleston Grey. Very elongated and oblong, light green striped variety with red flesh and hard rind, at maturity, rind colour turns to light green, fruits are sweet, juicy and crunchy, ideal for fresh market, tolerant to Fusarium and Anthracnose, drought resistant, matures in 80-85 days, average fruit weight: 8-10 kg and able to withstand long transportation

Agronomic practices

Land Preparation. Land should be prepared early enough so that the field is free of weeds and ready for planting at the onset of rains. The land should be prepared to a fine tilth and levelled so as to enhance moisture absorption and retention, easy germination and root penetration, ensures better surface contact between the seed and the soil and for uniform depth

Planting. Watermelon is propagated by seed that can be done directly in the field or raised on a nursery before transplanting. Seed rate is about 0.6-1.2 kg per acre depending on variety and spacing. The holes are dug at a distance of about 90-100 cm within the row and about 100-150 cm between the rows. Plant 2 seeds per hill, placing them 3-4 cm (1.5 inches) deep into the soil. This will give 2,666 - 4,444 plant population per acre. To hasten germination, soak seeds overnight

Fertiliser Requirement. Well composted manure should be broadcasted (8 tons per acre) then worked into the soil (incorporated) preferably using a hoe. Alternatively, apply a handful per planting hole before sowing. Manure/compost should be applied 1-2 weeks before sowing the watermelon and incorporate into the soil 80 kg per acre of TSP or DSP. CAN top dressing fertiliser is applied in 2 splits; 1st split application: when the plants start to run (40 kg per acre) and the 2nd split application: when plants are about to flower (80 kg per acre).

Water Management. Water deficit during flowering and fruit development causes serious yield reduction. Irrigation is important to ensure consistent moisture availability. Excessive irrigation makes mature fruits to split / crack, tasteless and watery

Weed Control. Watermelon has a shallow root system therefore care should be taken to avoid bruising the roots during weeding, The frequency of weeding depends on weed infestation; generally keep the field weed-free as much as possible to avoid competition for nutrients, sunlight and moisture. This can be done through use of appropriate weeding tools. Weeding watermelon field when the soil is wet can increase the spread of some bacterial (Bacterial Wilt) and fungal (Fusarium Wilt) diseases.

Mulching. It is a recommended crop management practice for Watermelon production. Mulching could be done using straw or dry leaves. Its advantages include; Moisture conservation, Weeds suppression and Prevents fruits from being in contact with soil and thus prevents pest and disease attack. The fruits need to be turned regularly to ensure uniform fruit colour development

Pruning. Remove any dead, diseased, yellowing or infested leaves or shoots at the joint where they connect to the main stem. Remove deformed and blossom-end rot fruits. Maintain 2-3 vines and remove extra vines. If the market demands larger melons, leave 3-4 well shaped melons per plant. Do not prune when vines are wet.

Pests

Pest damage causes reduction in quality and quantity of produce. Major pests of Watermelon in Kenya: Melon Fly, Aphids, Spider Mites, White Flies, Epilachna Beetles and Root-knot Nematode (Table 2.11).

Table 2.11.Watermelon pests and management options

Pest	Damage symptom	management
Melon Fly		Field Monitoring/ Biological control Cultural Control Chemical Control, Use of pesticides, such as; Deltamethrinand Trichlorfon
Spider Mites		Adequate irrigation Mulching to conserve water Predatory mite Spray with miticides, such as Bifenthrin
White flies		Use of pesticides such as: Lambda-cyhalothrin Thiamethoxam

Table 2.11.Watermelon pests and management options

Aphids		Ensure plants are not water stressed Use of pesticides, such as Azadirachtin and Deltamethrin
Root-knot Nematode (*Meloidogyne spp*.)		Cultural control Crop rotation Use of resistant varieties Chemical control Use of ethoprophos and azadirachtin

Diseases

Disease infection leads to reduction quality and quantity of produce. Major diseases of watermelon include; powdery mildew, anthracnose, downy mildew, fusarium wilt, Black rot and root-knot Nematodes (Table 2.12)

Table 2.12. Watermelon diseases and management options

Disease	Damage symptoms	Management
Anthracnose		Crop rotation Plant clean seeds Use of fungicides, such as; Copper Oxychloride, Mancozeb and Azoxystrobin + Difenoconazole
Powdery mildew		Use of fungicides, such as Sulphur, Famoxadime+Cymoxanil and Azoxystrobin + Difenoconazole
Downy Mildew		Cultural Control; Reduce canopy density • Chemical Control; Mancozeb (Milthane Super®, Penncozeb, Propineb + Cymoxanil and Dimethomorph + Mancozeb
Fusarium Wilt		Crop rotation Rouging/removal and destruction of diseased plants Plant in well drained soils and avoid water logging Use of certified seed Use of well decomposed manure and compost

Harvesting indices

- Tendrils near fruit stem have changed colour from green to brown
- Ground spot on the belly of the melon has changed from white to yellow
- The fruits when thumped with the hand produce muffled dull tone (immature fruits produce clear metallic ringing tone)
- Leave the stalk attached to the fruit
- Mature fruits have sweet flavour, crisp texture and deep red colour
- Sugar content (measured as soluble solids by use of hand held refractometer) of 10 % or more in the flesh near the centre of the melon. Yields: 25,000-50,000 kg per acre

Main harvesting stages; Mature but before full ripeness for distant markets and Mature and ripe for nearby markets

Notes: Watermelons don't ripen after they are picked so harvest time is important, If harvested immature, red colour will develop but sugar content does not increase after harvest and Harvesting should be done by cutting the vine and NOT pulling, twisting or breaking off the vines

Further reading

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Capsicum/ bell pepper (*Capsicum annuum*)

Green and red Capsicum Photo Source: SHEP PLUS

Capsicum/bell pepper, also called sweet pepper. It is a horticultural vegetable crop that belongs to the family Solanaceae. It has a mild flavour, not hot and rich in vitamin A and C with natural elements such as Potassium and Phosphorous

Ecological requirement

The ideal growing conditions for capsicum include, altitude range of 0-2000 metres above level, rainfall of between 600-1200 mm p.a, temperature range 0f 18-30 ^{O}C. The crop does well on well drained loamy soils with PH of 5.5-6.8 and high in organic matter content.

Varieties

There are two main types: determinate (open field) and Indeterminate (greenhouse) varieties.

- Determinate varieties: are bushy with defined growth and development period. Examples include Yolo Wonder and California Wonder
- Indeterminate varieties: achieve growth through a single apical stem with few secondary branches. Examples Commandant F1, Admiral F1, Nemalite F1, Green Bell F1

California Wonder is:

- Suitable for home and market gardening
- Fruits are thick walled, 4 lobed, blocky and compact
- Yield: 6,000 kg per acre

Yolo Wonder

- A popular variety for export and local market
- Fruits are shiny dark green, 3-4 lobed, firm and blocky
- It is vigorous, compact and high yielding
- Yield: 6,000 kg per acre

Commandant F1

- Grown both in open field and greenhouse
- Resistant to Potato virus, Tomato mosaic and Tobacco mosaic, pepper mild mottle and bacterial spot
- Has long harvesting period: 10 weeks and 4-6 months for open field and greenhouse, respectively
- Fruits can be harvested green (75 days) or red (90 days)
- Yield: 25,000-30,000 kg per acre (open field), 50,000- 60,000 kg per acre (green house)
-

Admiral F1

- Can be grown in open field and greenhouse
- Has similar characteristics to Commandant F1
- Fruits can be harvested green (75 days) or yellow (90 days)
- Yield: 25,000-30,000 kg per acre (open field), 50,000-60,000 kg per acre (green house)

Agronomic practices

Land Preparation. Land should be prepared early enough so that the field is free of weeds and ready for planting at the onset of rains. The land should be prepared to a fine tilth and levelled so as to enhance moisture absorption and retention, easy germination and root penetration, ensures better surface contact between the seed and the soil and for uniform depth.

Planting. The crop is normally raised in nursery before transplanting to the main field but it can also be directly sown. Nursery for capsicum should be selected/sited in an area that has not been planted with the crop from the same family at least not less than 2 years and should be well drained. Seedlings are ready for transplanting when they are at 4-6 true leaf stage or 6-8 weeks after transplanting. The recommended spacing is 60 x 45 cm or 70 x 30 cm depending on the variety

Fertiliser Requirement. The choice, type and amount of fertiliser for use will depend on the soil analysis report. The recommendation is to apply 100 kg per acre of DSP/TSP during transplanting. It should be mixed well with the soil to avoid scorching and burning of the roots. Top dressing should be done with organic and inorganic/chemical fertilisers to produce high yields but the general recommendation is that; 1st top-dressing to be done with 40 kg per acre of CAN 2-3 weeks after transplanting and the 2nd top-dressing is done with 80 kg per acre of CAN 4-6 weeks after transplanting. During flowering high amounts of nitrogenous fertiliser should be avoided

Training and Staking. To keep the plant upright and also keep the fruit clean by avoiding contacts with the soil. It keeps canopy intact and preventing fruits from sunscald, holds heavy loaded fruit to avoid splitting/breaking out from the stem and minimise lodging

Weeding; It is a critical practice that needs to be timely done during the vegetative growth stages of the crop. It should start 3 weeks after transplanting to minimise competition and harbour other pests

Pests

Major insect pests are; White Fly, Root-Knot Nematode, Aphid, Cutworm, Spider Mite, Fruit Borer, Leaf Miner and Thrips. Their management include:

- Use traps like sticky traps
- Conserve natural enemy
- Spray with the recommended pesticide
- Practice Crop rotation and mixed cropping
- Timely weeding and field hygiene
- Routine scouting of the crop field

Diseases

Major diseases of Capsicum; Damping-off, Anthracnose, Leaf Spot, Fusarium Wilt, Powdery Mildew, Viral Diseases, Bacterial Soft Rot, Bacterial Wilt and Blossom End Rot. Their managemnet include:

- Proper site selection
- Growing of certified seeds
- Proper water management
- Spray with the recommended chemical
- Practice good field sanitation
- Practice proper soil fertility management and crop rotation
- Management of the vector

Harvesting

Maturity period ranges between 2-3 months after transplanting. Harvesting can be done at harvestable-green colour or when they have developed full colour. Green fruits are incapable

of ripening after removal from the plant. The right stage for coloured fruit is when they have reached full colour, filled out, still firm, sticky and thick walled. Care should be taken during harvesting Since Capsicums have soft pliable thin flesh. Use clean knife or scissors to harvest the fruits. Fruits should be harvested early in the morning when it is cool since the fruit temperature is low. Harvested fruits should be kept in a cool, shaded and ventilated area in order to minimise heat gain. Yield ranges: 6,000-60,000 kg/acre depending on the variety and crop husbandry.

Further reading

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Tomato (*Solanum lycopersicum* L.)

Tomato fruits Photo source: Farmbiz Africa

Tomato is one the most produced and consumed vegetables. It belongs to the solanaceae family. It is an important cash crop for smallholder farmers and is produced both in open fields and in the greenhouse. Tomatoes are consumed raw in salads, used in cooking, processed to jams paste and juice.

Varieties

Rio Grande

- Determinate
- Fresh market and processing variety
- Plant is slightly bushy and can be staked or left unstaked
- Tolerant to verticillium and fusarium wilt
- Maturity Period: 75-85 days after transplanting
- Yield: 18,000kg per acre

Assila F1

- Determinate early maturing (75 days) variety
- Tolerant to Tomato Yellow Leaf Curl Virus (TYLCV) and nematodes
- It produces fruits with attractive red colour with oval shape and heavy sweet fruits
- Yield: 23,000kg per acre
- Good keeping quality and transportability

Kilele F1

- Determinate type Medium - early maturing variety
- Suitable for drier or humid areas
- Disease tolerance: Tomato Yellow Leaf Curl Virus, Tomato Mosaic Virus, Verticillium, Fusarium Wilt and Nematodes
- Fruits: Firm and elongated and has shelf life of 21 days
- Maturity Period: 75 days after transplanting
- Yield: 30,000-35,000 per acre

Cal J

- Open pollinated determinate variety
- Tolerant to verticillium and fusarium wilts
- The plant produces red blocky shaped fruits
- The fruits store and transport well
- Maturity Period: 75-85 days after transplanting
- Yield: 11,000-13,000 kg per acre

Eden F1

- Determinate and vigorous growing variety
- Good tolerance to Alternaria Canker, Verticillium Wilt, Fusarium Wilt, Nematodes and Bacterial Speck
- Deep red blocky fruits have long shelf life
- Maturity Period: 75 days after transplanting
- Yield: 40,000-50,000 kg per acre (9-10 kg per plant)

Rambo F1

- Determinate, vigorous plant with uniformly set and firm fruits
- Tolerance: Bacterial wilt, Bacterial spot, Fusarium wilt, Verticillium wilt and Nematodes
- Maturity 75 days after transplanting
- Yield: 30,000 kg per acre
- Good shelf life and transport quality

Anna F1

- Hybrid and indeterminate fresh market variety that produces blocky oval red fruits that have a long shelf life, tolerance to Fusarium, Verticillium Wilt, ℃℃℃Alternaria Stem Canker and Nematodes
- Ideal greenhouse Tomato
- Maturity Period: 75 days after transplanting
- Yield: 64,000 kg per acre (18 kg per plant for 8 months)

Ecological requirements

- 0-2000 m
- Over 600 mm annual rainfall in open field
- Day temperatures of 20-25℃ and 15-16 ℃ at night
- Well drained sandy loam and clay loam soils

Nursery establishment

- The nursery site should be at a place where other solanaceae crops have not been grown before
- A nursery bed should have a width of 1metre and of convenient length
- Drills should be made 10-20 cm apart
- Seeds should be thinly sowed and covered lightly with soil
- The nursery should be watered regularly and the seedlings hardened 1-2 weeks before transplanting
- Insects such as whiteflies can transmit viruses to young tomato plants hence should be controlled using pesticides e.g. Amitraz (Mitac 20EC®), Buprofezin (Applaud 40%SC®), Azadirachtin (Nimbecidine®), Imidacloprid (Confidor 70 WG®)
- These insects can be blocked from reaching the seedlings by use of an insect proof net (agricultural type)

Transplanting

- Seedlings are transplanted 30-45 days after sowing
- Transplanting should be done early in the morning or late in the evening
- The spacing should range from 70-100 cm between the rows and 40-60 cm between seedlings depending on the variety
- Apply 2-3 handfuls of manure per planting hole (8 tons/acre)
- Apply 2 bottle tops (10 g) of Triple Super Phosphate (TSP) per planting hole (80 kg/acre Apply Muriate of Potash (MOP) to enhance availability of potassium

Tomato Management Practices

- Training and staking- indeterminate varieties should be staked to facilitate pruning harvesting and other cultural practices. Staking is done using strings and wooden or bamboo stakes
- Determinate varieties could be trained in the wet season or mulched to prevent the fruit from touching soil
- Pruning should be done for the indeterminate varieties extra shoots and flowers should be removed to improve quality, increase tomato size and promote early maturity

Tomatoes are attacked by different pests (Table 2.13) and diseases (Table 2.14).

Table 2.13. Tomato pests and management options

Pest	Symptoms	Management
Tobacco Whitefly *Bemisia tabaci*		-Keep tomato fields weed-free -Use of yellow sticky traps to monitor their population levels Cover -omato seedling nurseries with nylon nets or insect proof nets to protect seedlings from Whitefly infestations -Use of insecticides; Amitraz,Buprofezin, Azadirachtin, Imidacloprid, Lambda Cyhalothrin, Lambda, cyhalothrin + Thiamethoxam

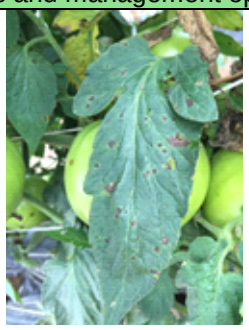
Table 2.13. Tomato pests and management options

Tuta absoluta		-Early control is important before the pest pressure builds up -Carry out cultural practices like field hygiene, crop rotation -Carry out regular scouting/monitoring of pest population -Use of pheromone traps to attract male insects for both monitoring/surveillance and pest control e.g.) mating disruption, mass trapping 'lure and kill' method, such as Tutak traps -Use of biological control agents, such as - Chlorantraniliprole, Indoxacarb, Spirotetramat + Flubendiamide, Thiocyclam 50% w/w; Thiocyclam-hydrogen oxalate and - Imidacloprid, Flubendiamide (Belt 480SC®) -The above pest control tactics should be combined in an IPM strategy
African bollworm *Helicoverpa armigera*		-Tilling and ploughing of old tomato field exposes pupa to desiccation and natural enemies -Planting of trap crops (Cucumber, Maize and mexican Marigold) which attract the pest before it attacks tomatoes (Need to synchronise planting of both maize and tomatoes so that they flower at same time) -Use of selective pesticides, such as microbial control agents: – Helicoverpa armigera NPV Virus (Helitec SC®) – Indoxacarb (Avaunt 150SL®) – Etofenprox 30%(TREBON 30 EC®)

Table 2.14. Tomato diseases and management options

Disease	Symptoms	Management
Late Blight *Phytophthora infestans*		-Crop rotation -Removal of all volunteer crops that are more susceptible to this disease -Pruning and staking in order to improve air circulation and reduce humidity -Use of fungicides, such as: – Metalaxyl + Mancozeb (Ridomil Gold MZ68®), Propineb + Cymoxanil (Milraz WP76®), Mancozeb (Dithane M45®), Dimethomorph + Mancozeb (Acrobat MZ®)

Table 2.14. Tomato diseases and management options

Early Blight *Alternaria solani*		-Use of certified seeds -Appropriate spacing -Avoid overhead irrigation, water in the morning and keep plants healthy/ stress-free -Use of fungicides, such as; Chlorothalonil (Odeon® 82.5WDG), Manconzeb (Oshothane®), Propineb (Antracol WP70®), Mancozeb + Cymoxanil (Agromax®), Propineb + Iprovalicarb (Melody Duo®)
Bacterial wilt		-Practice crop rotation with crops such as cereals -Remove wilted plants, with the soil around roots, from the field and destroy -Solarize planting beds -Spot treatment with Sodium Hypochlorite at 10 % dilution (Jik) or with lime/ ash -Sterilise pruning tools -Use of Metam sodium (METHAM SODIUM 51 Liquid soluble®), Bronopol (ENRICH BM Wettable Powder®)
Fusarium wilt		-Use resistant tomato varieties (e.g. "Fortune Maker", "Rio Grande", "Tengeru 97", "Roma VFN“, “Eden F1”, “Rambo F1”, “Anna F1”). -Use certified disease-free seeds. -Do not locate seedbeds on land where Fusarium wilt is known to have occurred. -Where soil is acidic, raise the pH by applying lime or farmyard manure -Avoid excessive nitrogen fertilisation and control root-knot nematodes.

Harvesting and handling

- Maturity period ranges between 3-4 months after transplanting depending on: – The variety – Environmental conditions
- Tomato can be harvested at different stages depending on the market requirement and distance to the market
- There are four main harvesting stages: – Mature-Green Stage: where the fruit is green but internal gel is well developed – Breaker/turning Stage: up to 30 % of fruit surface has definite colour break from green to yellow – Pink/Light Red Stage: 30 – 90 % fruit surface has pink/red colour – Red/Ripe Stage: over 90 % fruit surface has changed to red colour
- Fruits should be harvested early in the morning when it is cool since the fruit temperature is low
- Harvested fruits should be kept in a cool, shaded and ventilated area in order to minimize heat gain
- Where necessary, wipe fruits to remove dirt

- The yields vary from 12,000-40,000 kg per acre depending on the variety and crop husbandry

Further reading

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Onion (*Allium cepa*)

Onion crop (Photo: Farmbiz Africa)

Onion is an important spice crop and it can be eaten raw or cooked. Onion is rich in Calcium, Iron, Potassium, Vitamin B6 and B9, Vitamin E and has medicinal properties

Varieties

Red Creole

- A popular variety which produces red, flat-round, globular bulbs
- It has very pungent taste
- Matures 150 days after transplanting
- Excelle storage qualities
- Yield Potential: 16,000 kg per acre

Bombay Red

- This variety is suitable for dry and warmer conditions
- Produces small to medium sized bulbs, which are globe shaped, Deep purple red colour and very pungent
- Matures 150 days after transplanting
- Yield Potential: 16,000 kg per acre
- Tropicana F1
- Very productive and produces large red, thick flat bulbs with firm pungent taste

- Yield Potential: 25 tons per acre
- Maturures 90-100days after transplanting

Texas Grano

- White colour with golden exterior
- The bulbs are relatively larger
- Matures 120 days from transplanting
- Does not have good storage qualities.
- It has mild pungency, which is good for salads
- Yield: 21,000 kg per acre

Red Pinoy F1

- Deep red attractive bulbs
- Matures 90 days from transplanting
- Strong pungency
- The variety has a long shelf life of up to 6 months at room temp
- Tolerant to Downy Mildew and Purple Blotch
- Yield: 30 tons per acre

Ecological requirements

- Onion can be cultivated up to 1,900 m above sea level
- Requires well-distributed rainfall of between 500 and 700 mm during the growing period.
- A dry spell is needed at maturity.
- The optimum temperature for growth is 15-30 °C. If the temperature exceeds 30 °C, maturity is hastened and small bulbs are produced, consequently lowering the yields. When the temperature is low, growth is slowed or the plant may result in flowering. Cold weather is also associated with increased leaf diseases.
- Requires fertile and well-drained soils.
- The optimum pH range is 6.0-6.8. Sandy to silty loams with fine tilth are adequate.

Nursery establishment and management

- Prepare beds maximum one metre wide and incorporate well-decomposed compost /FYM 20 kg/m2 and add DAP/TSP 20 g/m2
- Make rows about 15 cm apart, drill the seed thinly in 1cm furrows and cover lightly with soil and mulch
- Germination takes 7-10days

Transplanting

- Seedlings are transplanted 6-8 weeks after sowing or at 3-5 well formed leaves when base is pencil thick
- The seedlings are transplanted in 2.5-3 cm deep trenches at a spacing of 30 cm between rows and 8-10 cm between plants (when using furrow irrigation)
- Apply 80 kg/acre of TSP
- Irrigate field well a day before transplanting
- Carefully pull out the seedlings to avoid damage

- Cut off 50% of the green tops to hasten take off
- When planting onion sets, don't bury them more than one inch under the soil

Management practices

Topdressing

- Topdressing can be done in 2 splits
- 1st topdressing: 30 days after transplanting at 40 kg/acre of CAN
- 2nd topdressing: 45 days after transplanting at 80 kg/acre of CAN
- Strip/banding method is preferred over broadcasting as it is more effective
- Too much nitrogen results in thick necks
- Top-dressing should be completed before initiation of bulbing

Unearthing

- Unearthing is removal of excess soil around the bulb/loosening soil to allow the bulb to expand or develop well
- Unearthing can also facilitate the colouring and curing
- If the soil is hard during bulb formation, loosen the soil to allow bulbs to develop well
- Unearthing is carried out during 2nd and subsequent weeding and is done by removal of the soil from the bulbs by hand
- Watch out not to damage or expose the roots

Onions are attacked by different pests (Table 2.15) and diseases (Table 2.16).

Table 2.15. Onion pests and management options

Pest	Symptom	Management
Onion thrips		-Keep plants well irrigated since water stressed plants are more susceptible to thrips damage -Maintain weed-free plots -Rogue heavily infested plants -Neem extracts can be sprayed on attacked plants -Spray with insecticide, such as Spinosad (Tracer®), Abamectin + Acetamiprid (AMAZING TOP 100 WDG® PHI:21days), Acephate (ASATAF SP® PHI: 3-7days)
Onion Flies		-Practice crop rotation -Use well decomposed manure/compost -Practice field sanitation: remove and destroy infested plants -Carefully plough in crop residues immediately after harvest

Table 2.16.Onion diseases and management options

Diseases	Symptom	Management
Downy Mildew		-Field hygiene -Crop rotation -Use tolerant varieties e.g. Red Pinoy F1 -Use of fungicides e.g.) Mancozeb (Cadilac®, Dithane M45® etc.)
Purple Blotch		-Use resistant varieties e.g. Red Passion F1 and Red Pinoy F1 • Crop rotation -Field Sanitation: remove crop remains after harvest, do not leave volunteer plants in the field Avoid over fertilisation

Table 2.16.Onion diseases and management options

		-Use- recommended spacing and good drainage to decrease humidity in the plant stand -Use of fungicides such as Mancozeb (Dithane M45®) Difenoconazole (Domain 25% EC®), • Propineb + Cymoxanil (Milraz WP 76®) • Eugenol (e.g. Explorer 0.3 SL®)
Onion Rust		-Crop rotation -Application of proper agronomic practices: proper nutrition and spacing -Use of fungicides: – Mancozeb (Dithane M45) – Difenoconazole (Domain 25% EC®) – Eugenol (Explorer 0.3 SL®)
Neck Rot		-Use fungicide treated seeds or sets -Avoid damaging onion bulbs at or during harvest -Don't bend over foliage to hasten drying out -Only harvest onions when the necks have ripened and fallen over on their own accord. -Avoid using high nitrogen fertilisers -Crop rotation at least 3 years -Dry the bulbs out thoroughly after harvest -Good ventilation is more important in the drying process than the sun. -Store only bulbs with dried out thin necks -Store bulbs in a cool and dry place -Sort out bulbs which show signs of rot.

Harvesting and handling

Harvesting indices. Harvesting can be done 90-150 days after transplanting depending on the variety. Bulb Onions are ready for harvesting when the leaves collapse or when 75% of the tops of the crop have dried and fallen over. Leaf tops begin to discolour, bend and dry towards the ground. Reduced thickness of sheath leaves surrounding the bulbs.

Curing. Curing is a process intended to dry off the necks and outer leaves of bulbs. The main objective is to prolong shelf life by preventing moisture loss and attack by diseases. It can be done in the field or in a protected environment away from adverse weather conditions, such as rain or direct sunlight.

Field Curing. Curing can be done in the field if the maturity and harvesting coincides with dry months. Harvested onions are placed in rows with leaves partially covering the bulbs to prevent sunburn or greening. Onions are then left in the field until the outer leaves and neck are completely dry and papery. Field curing can take 2-3 weeks depending on the environmental conditions.

Protected Curing. Curing is done in a warm, dry and well-ventilated location protected from direct sunlight and rain. The process involves removal of excess soil (trimming of foliage leaving 2.5 cm of section of stem at neck – Placing onions in single layer in large flat tray)

Onions can also be cured by tying tops of bulbs in bunches and hanging on a horizontal pole in well ventilated shade.

Further reading

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