**CROP PRODUCTION MANAGEMENT-ANNUAL CROPS**

**1. CEREAL CROPS**

**MAIZE (Zea mays)**

Maize is the most important cereal/food crop in East Africa. The crop originated from Central America (Mexico). The crop was brought to Kenya by Portuguese traders in the 16th C and since then it has become a staple food. The chief growing areas are [Trans Nzoia](http://softkenya.com/trans-nzoia-county/), [Nakuru](http://softkenya.com/nakuru-county/), [Bungoma](http://softkenya.com/bungoma-county/), and [Uasin Gishu](http://softkenya.com/uasin-gishu-county/) [counties](http://softkenya.com/county/).

**Problems facing maize farming in Kenya**

* **High cost of production -** Expensive farm inputs e. g. fertilizers which reduce the farmer’s proﬁts.
* **Unstable prices -** Fluctuating prices makes it hard for the famer to plan or at times to even recover their inputs.
* **Climatic hazards** – Prolonged drought or unfavorable weather conditions lead to destruction of the crop leading to low yields and income for the farmer.
* **Competition** – Flooding of the local markets by cheap imports from COMESA countries and heavily subsidized. maize from the European Union or even from genetically modified grains.
* **Pests and diseases -** These attack the crop or even the harvested grains leading to destruction hence loss to the farmers.
* **Monoculture** - Prolonged planting of maize has led to soil exhaustion.
* **Poor marketing strategies** – These has resulted in farmers selling their

**Types of maize based on kernel characteristics**

1. Pod corn (Zea mays tunica)

The kernels are enclosed in a pod

2. Popcorn (Zea mays ……

Kernels are short with a high percentage of endosperm starch.

Has ability to pop due to rapid expansion of moisture in each individual grain upon application of heat.

3. Flint corn (Zea mays indurata)

The kernels have endosperm with soft starch in the center completely enclosed with a very hard outer layer. The kernels shrink uniformly as the mature.

4. Dent corn (Zea mays indentata)

Kernels are characterised by a depression or dent in the corn due to shrinkage during ripening. It’s the mostly cultivated type.

5. Flour corn (Zea mays amylacea)

Has soft starch with thin layer of hard starch on the side.

6. Sweet corn (zea mays saccharata)

Kernels are succulent wuth high starch and sugar content.

7. Waxy corn (Zea mays ceratina)

The endosperm looks waxy when the kernels are broken. Used for making adhesives (glues) in textile industries.

**Economic importance**

* Staple food especially mixed with legumes.
* Animal feeds(silage making)
* Preparation of green manure
* Used in industries for manufacture of starch/glucose etc.

**Advantages of maize over other crops**

* High yielding potential than other indigenous crops
* Less seriously damaged by pests and diseases
* No threshing or winnowing required
* More palatable and therefore preferred
* Can be produced both in small and large scale
* Requires less labour during cultivation
* Adapted to wider ecological zones/climatic conditions

**Plant characteristics**

* Have narrow, elongated leaves with parallel veins.
* Growth habit is erect
* Single stem crop growing to a height of between 1-4.5m depending on cultivar
* May have tillers due to high soil fertility
* Both male and female flowers are produced on the same flower but at different places.
* The tussles is the male part, emerges at the top of the plant and sheds pollen over a period of one week
* Mostly cross pollinated(only 5% is self-pollinated)
* Maize has three types of roots: seminal roots, feeder roots, fibrous/adventitious roots and prop roots

1. Seminal roots-are the first roots arising from the seeds and are usually 4 in number
2. Adventitious roots-are formed from the nodes above the seed. The function is to absorb water and nutrients from the soil
3. Prop roots-arise from the nodes above the ground and they offer support/anchorage to the standing crop.

The depth of the roots depends on the soil and rainfall but can reach a depth of 3.6M.

**Ecological requirements**

1. Soils – can grow in a wide range of soils but performs best in well drained and aerated loam or silty loams or alluvial soils with a PH of 5.5-7.0.

Young maize is intolerant to water logging during the early stages of growth (4-5weeks) because the roots are below the soil surface.

1. Altitude- can grow in a wide range of AEZs ranging from 0-2200m ASL depending on variety.
2. Temperature- Maize is a versatile crop, growing across a range of agro-ecological zones. Maize has a wide range of tolerance to temperature conditions. It is essentially a crop of warm regions where moisture is adequate. The crop requires an average daily temperature of at least 20°C for adequate growth and development. Optimum temperature for good yields is around 30°C. The time of flowering is influenced by photoperiod and temperature. Maize is considered to be a quantitative short-day plant (short days can induce premature flowering).
3. Rainfall- maize grows well between 600-900mm rainfalls. Should be well distributed throughout the growing period. Rainfall is most critical at flowering and silking stage. Drought at flowering time interferes with pollination and drastically reduces yields. Towards harvesting, dry conditions are required to facilitate drying of the grains and to reduce incidences of rotting.

**Varieties**

The choice by farmers depends on the following factors;

* Speed of growth(seasonality)
* Altitude(Zone) and temperatures
* Weather conditions(long/short rains)
* Soil type/fertility
* Productivity both in terms of the comb size and dry matter for forage feeds.
* Cultural practices-most are small scale farmers and intercropping is a common cultivation practice
* Days to maturity
* Food preference-in terms of grain size, colour and taste.
* Provision of animal feeds

Recommended varieties by zone

|  |  |  |
| --- | --- | --- |
| **Eco zone** | **variety** | **Maturity period** |
| 1. high land with high rainfall  Altitude: 1500-2100m ASL  Areas: T/Nzoia,Uasin gishu,Nakuru,kericho,Nandi, Bungoma Laikipia, Kisii, Narok and tea zones of C& E provinces. West pokot, Nyeri,lower Nyandarua and upper Kiambu | H627,H626,H625,H614,H6213,  H6210,H6212,H629,H628, | 6-8 months |
| 2. Highland zzones with high rainfall  Altitude: 1000-1700m ASL  Areas: Baringo,siaya,Kisumu,Busia,Bungoma,Kakamega,Nakuru  T/nzoia and T/taveta | H632,H622,H521,H519,H518 | 6-8 months and 5-6 months |
| 3. Coffee zones with medium long growing season  Altitude: 1000-1800m ASL  Areas; coffee zones of C&E provinces,Kisii,Narok,Nakuru,Siaya,Kisumu,Busia,KK,BGM and Keiyo Marakwet | H513,PH B 3253,H512,H511,CG 4141,CG 5222,H516,H515 AND SIMBA 61 | 4-6 months |
| 4. Lower altitude zone with less rainfall(ASALs)  Areas; machakos, makueni, coast, north eastern | Katumani, coast composite, makueni composite, Duma 43, DH 02/04 | 3.5-4 months |

NB; Seeds of hybrid maize should not be saved and planted the following season because of segregation and loss of hybrid vigour. Given that maize is also 95% cross-pollinated. This will lead to yield reduction by more than 25-30%.

**Planting**

1. Land preparation

The land should be prepared during the dry season to reduce pests, diseases and weeds build-up. Deep turning of crop residues and weeds hastens decomposition increasing the fertility of the land.

2. Sowing

Maize seed is planted manually by dibbling or on large scale by planters. 2 seed are planted per hole at least 2.5-5cm deep, but in dry soils the seeds are placed up to 10cm deep to prevent drying and germinating as a result of light showers.. The seeds should be treated with fungicides to reduce rots and seedling blights. Two seed per hole is recommended. Is usually intercropped with legumes.

**Reasons why late planting gives poor yields**

* For the crop to capture most of the seasons rainfall so that the crops do not suffer moisture deficiencies during the critical stages of growth such as flowering and grain filling.
* To avoid last minute input rush by the farmers which may lead to shortages of inputs such as seeds, fertilizers and labour.
* Decline in soil temperature as the rain progresses. This may cause slow/poor germination. Also, young maize is sensitive to low soil temperature because the growing points are below the soil.
* Late planting causes poor aeration of the soil because the soil pores are filled with water creating water logging and anaerobic conditions. This interferes with decomposition and mineralization of organic matter.
* The crop should be planted early so that it benefits from the nitrogen flush (birch effect).this is a high concentration of N in the soil that occurs immediately after the rains.
* To avoid/enable the crop to escape pest and diseases which occur late in the season.
* Yields increase 15-20% have been recorded in earlier planted maize due to warmer weather during seedling emergence

**3. Spacing**

Plant population and spacing depends on variety and AEZ.A spacing of 75x30 cm is recommended for the tall high hybrids/highland varieties giving a population of 44,000plants/Ha. Spacing of 90x30cm is adopted for dry land hybrids e.g. Katumani. This gives a plant population 0f 36,000 plants/Ha

The seed rate for maize is 10kgseeds/acre.

**4. Fertilizer application**

A Phosphatic fertilizer such as DAP should be applied in the planting holes in the time of sowing at the rate of 50kg/acre or 1 bag/acre. (250kg/Ha or 2-3 bags/Ha)

Organic manure should also be applied and incorporated before planting at the rate of 3T/Ha.

A correct balance of N and K has to be maintained. Excess N leads excess succulence causing stalk lodging.

Top dressing is done two split application in high rainfall areas.1st split is done 6 weeks after sowing(knee high).During this time,1st weeding and pulling soil to the base (earthing up) should be done. 2nd dose is applied 10-15 days later but before tasseling (flowering) to avoid damaging the lateral roots.

In low rainfall areas and heavy soils,50% of N is applied at planting along with total amounts of P&K.the rest 50% should be applied as top dress 30-45 days after sowing. The rate of CAN application is 90kg/acre and 20kgKCL/acre. Apply one teaspoonful at the base of each plant, 15cm away from the plant to avoid scorching.

The soils should be moist.

**5. Thinning and gapping**

Thinning and gapping occurs simultenoulsly.This is done when the crop is15cm tall to leave one seedling per hole

**6. Weed control**

Can be done mechanically or chemically using herbicides. Manual weed control requires 2-3 weeding operations during which the crops are earthed up to reduce lodging. The first weeding is done within the 3rd week after planting or depending on the growth of weeds in the area. The field should be kept weeds free until maize tassels after which their presence may not cause crop loss.

Herbicides; 2, 4-D (post emergence) are used at the rate 0.75L/Ha.

Lasso/Atrazine (pre-Emergence) 2-3 L/Ha

The most serious weed is Striga. This is a parasitic weed on cereals. Is common in Coast, Nyanza and western Kenya. Control options include;

-Uprooting and physical destruction of weeds before flowering

-Application of high doses of FYM (25T/Ha)

-use of fertilizers especially ASN

-Crop rotation with trap crops such as sunflower, soya beans and ground nuts

-intercropping with desmodium to suppress the weed

**7. Irrigation**

The most critical water requiring stage is flowering and grain filling. Drought during vegetative growth results in small plants with reduced leaf area. About 60cm of well distributed rainfall during growing season is sufficient for the crop.

**Maize diseases**

**Maize streak virus (MSV)**

This is transmitted from healthy crops by leaf hoppers (*Cicandulina mbila*)

Damage symptoms

The virus causes a white to yellowish streaking on the leaves. The streaks are very narrow, broken and run parallel along the veins.

Eventually the leaves turn yellow with long lines of green patches.

Plants infected at early stage do not produce any cobs (are barren)

Control

* Use of tolerant/resistant varieties
* Early rouging
* Eradication of grass weeds
* Avoid overlap of two maize crops
* Crop rotation
* Use of certified seeds

**Maize lethal necrotic diseases**

This is a recent maize disease in Kenya. The disease was first identified in the USA in 1976 (Niblett and Claflin 1978). MLN is caused by the double infection of maize plants with Maize chlorotic mottle virus (MCMV) and any of the cereal viruses in the Potyviridae group, such as Sugarcane mosaic virus (SCMV), Maize dwarf mosaic virus (MDMV), or Wheat streak mosaic virus (WSMV). MCMV or SCMV typically produce milder symptoms when they infect maize alone; in combination, these two viruses rapidly produce a synergistic reaction that seriously damages or kills infected plants.

Maize plants are susceptible to MLN at all stages in their growth, from seedling to maturity. As with all viral diseases in plants, a carrier—known as a “vector”—transmits the MLN-causing viruses from plant to plant and field to field. MCMV is carried by thrips and beetles (Nault et al. 1978; Jiang et al. 1992) and SCMV by aphids (Brandes 1920; Pemberton and Charpentier 1969). Transmission of MCMV via seed from infected plants is normally very low (0.04%; Jensen et al. 1991).

Typical Disease symptoms

* Yellowing of the plant
* Mottling starts from the base of leaves and extends upwards towards the leaf tips
* Stunting and premature aging of the mature plants
* Drying or necrosis of the leaf margins that progresses to the midrib and eventually affecting the whole leaf
* Necrosis of young leaves in the whorl before expansion leading to ‘’dead heart’’ symptoms and eventually death.
* Infected plants are barren and ears formed may be small or deformed and sett little or no seed.

Control

• MLND does not occur on crops other than maize; so avoid growing maize after maize. Diversify your farm enterprise by planting different crops each season (crop rotation).

• Do not plant a new maize crop near an infected field. Wind-blown insect vectors can transmit the disease from the infected field to the new crop.

• Plant maize at the onset of the main rainy season, rather than during the short rain season; this creates a break between maize crops and interrupts the disease cycle.

• Weed fields regularly to eliminate alternate hosts for insect vectors. Also control insect vectors by spraying with insecticides.

• Use maize varieties that are resistant to MLND.

* Early planting

• Immediately remove diseased plants from your fields. You can feed the leaves to livestock.

• Do not allow humans or animals to eat infected ears or grains, which may contain secondary fungal infections and harmful mycotoxins. Burn infected ears and grains.

* Use manure and fertilizer to boost plant vigor.

**Common smut**

Caused by the fungus *Ustilago maydis.*

They typically produce black powdery spore balls in parts of the plant such as flowers, seeds, leaves, stems and even roots. Affected parts eventually break open to release the characteristic sooty masses of spores. Plants attacked by the boil smut fungus develop tumours on all aerial parts including the prop roots. The infected plants do not produce any grains.

Control

* Use of certified seeds
* Crop rotation
* Use of resistant varieties
* Rogue and destroy by burning the affected plants

**Head smut**

Caused by the fungus *Sphacelotheca reiliana*

Head smuts cause significant damage in dry, hot maize growing areas such as in medium elevations and wet rainy conditions. The infection is systematic whereby the fungus penetrates the seedlings and grows inside the plant without showing the symptoms, until the tasseling and silking stages. The major symptoms are;

* Abnormal development of tassels, which becomes malformed and over grown
* Black masses of spores that develop inside individual male florets
* Masses of black spores in place of the normal ear, leaving the vascular bundles exposed and shredded.

**Maize rusts**

Caused by the fungus *Puccinia sorghi.*

The disease is common in highlands with high humidity occurring at tasseling.

The symptoms are small elongated powdery pustules seen over both surfaces of the leaves. Pustules are dark brown in early stages of infection. Later, the epidermis is raptured and lesions turn black as the plant matures.

Control

* Use of resistant varieties
* Crop rotation
* Deep ploughing of crop residues
* Destruction of weed such as oxalis as it acts as an alternative host
* Use of foliar fungicides in seed production fields

**Maize leaf blight**

Caused by the fungus Helminthosporium maydis or Bipolaris maydis.

Disease development is promoted by prolonged wetness on foliage, extended dew, RH OF 97-100% warm temperatures between 24-350C.

Symptoms

Yellow small dots that become elongated between veins.they later become brownish to cream white in colour with reddish to purplish brown borders.the spots may join together and result in blighting of entire leaves.silks,portions of the husks and cobs may turn black.a black mould aslo may develop on the cobs.

Control

* Use of tolerant/resistant varieties
* Field hygiene and removal of residues after harvesting.
* Deep ploughing and incorporating of crop residues
* Sowing certified seed.

**Pests**

**Maize stalk borers (Busseola fusca)**

Stem borers are the most important insect pests of maize in sub-Saharan Africa. Yield losses vary between 10-70%. Several species have been reported. At least four species attack maize in eastern and southern Africa, with yield losses reported to vary from 20 to 40%, depending on agroecological conditions, crop cultivars, agronomic practices and intensity of infestation. The most important are the African maize stalk borer *(Busseola fusca*) and the spotted stem borer *(Chilo partellus*). The pink stalk borer *(Sesamia calamistis*) and the sugarcane stalk borer (*Eldana saccharina*) are of minor importance in maize. The adult is a dull, greyish brown moth with several white or silver spots in front wings. Fully grown larvae are cream coloured with faint purple markings and a dark band on head and thorax. The moths lay eggs in unfolded leaves/rolled. The young larvae make circular holes in straight lines across the newest leaves before boring tunnels on the stems as they become older. The larvae also feeds/bores tunnels on the stem.

**Control:**

* Conserve natural enemies. Parasitic wasps and predatory ants are important in natural control of stem borers.
* Remove and Destroy crop residues to kill pupae left in old stems and stubble and prevent carry-over populations. This helps in limiting initial establishment of stem borers on the following season's crops.(field sanitation)
* Intercrop maize with crops that are non-hosts for stem borers (e.g. cassava and grain legumes)
* Intercrop maize with a repellent plant such as desmodium and plant an attractive trap plant, such as Napier grass, as a border crop around this intercrop to protect maize from stem borers. This technology is known as "**push-pull**".
* Use Neem products. Simple Neem products are reported to be effective for control of stem borers. Place a small amount of Neem powder (ground Neem seeds) mixed with dry clay or sawdust at a rate of 1:1 in the funnel of the plant. One kg powder should be sufficient to treat 1500 to 2000 plants. Rainwater dissolves the active substances in Neem powder as it gathers in the funnel and washes out the powder. Where rainfall is irregular a liquid Neem seed extract can be sprayed into the funnel.
* Apply insecticides such as thiodan/bulldock 2kg/ha or a pinch into the funnel of the plant at knee height stage when there is adequate moisture before the larvae moves down the stem.
* Early planting reduces the severity of damage.

**The larger grain borer (*Prostephanus truncatus*) and the grain weevils *(Sitophylus spp*.)**

They attack stored maize grains. Both the adults and the larvae (grubs) of these beetles feed in the grains. Adults come from infested cobs in the field or from an infested maize store and lay eggs in the grains. They attack maize both in the field and after harvest. Attacked maize grains lose all their contents and are not fit to eat. These pests become a serious problem in short time if not control measures are applied. The larger grain borer also attacks dried cassava roots and even the wooden structures of the stores.

Control:

* Conserve natural enemies. An imported predatory beetle Teretrius (formerly Teretriosoma) nigrensis has been released in several African countries in an attempt to control the larger grain borer.
* Dusting grains with chemicals like actellic super and cleaning the store before storing grains
* Early harvesting
* Proper drying of grains properly to moisture content of 12-13% before storage
* Use of fumigants such as celphose, quickphos, gastoxin in NCPB and other large grain handlers.

**Army worms (*Spodoptera exempta*)**

The African armyworm is a very damaging pest, capable of destroying entire crops in a matter of weeks. Although they are regarded as occasional pests, in an outbreak large number of caterpillars will appear destroying the whole plant to ground level. They damage the crop by feeding on the leaves until only the midrib remains. The worst outbreaks seem to occur when the onset of rains is delayed.

Control;

* Monitor regularly field margins, low areas where plants have lodged, beneath plant debris around the base of plants, on the ground, and underneath the plant leaves. Check daily young crops if conditions are known to be favourable to the pest.
* Spray Bt or botanicals such as Neem and pyrethrum extracts. Spray when caterpillars are small. Once caterpillars are mature (about 3 to 3.5 cm long) they may have cause serious damage and it may no longer be economical to treat the crop.
* Conserve and encourage natural enemies.
* Use insecticides such as
* Practice field sanitation.

**Weeds**

**Purple witch weed *(Striga spp.)***

The parasitic weeds *Striga spp*. known as witch weeds, are important pests of maize, particularly in drier areas. The weeds grow on the roots of maize affecting development of maize plants. The young weeds tap the roots of maize plant and draw water and nutrients.

Reasons why Striga is difficult to control

* Ability to produce many viable seeds
* Ability to propagate vegetatively using underground rhizomes
* Seeds can remain in the soil for many years in case of unfavourable conditions and in absence of a suitable host
* Short life cycle
* Deep rooted
* Resistant to some herbicides since the leaves are tiny, waxy and sticky.

A single weed plant produces many thousands of tiny seeds that survive in the soil for long periods. A heavy infestation can cause complete yield loss.   
  
Striga weeds infest 40% of the arable land in the savannah region, causing annual crop losses of 7 to 13 billion dollars. Around the Lake Victoria basin infestation by *Striga hermonthica* causes 30 to 100% loss in maize yield. Striga infestation is associated with increased cropping intensity and declining soil fertility. Which weed infestation has resulted in the abandonment of much arable land by farmers in Africa. The problem is more serious in areas with low soil fertility and rainfall.   
None of these methods described will, alone, provide complete control and without complete control there is the certainty that surviving plants will mature and replenish the soil seed bank. Therefore, integration of one or more methods is essential for any substantial reduction of the problem. Furthermore, such integrated treatments will almost certainly need to be repeated over a number of years for long-term control.

**Control;**

* Weed regularly. This is the conventional method for striga control, but is time-consuming and labour-intensive.
* Rotate maize with trap crops. Some plants, such as such as sunflower, pulses and cotton, stimulate the germination of striga seeds, but also inhibit post-germination growth of the weed. Thus, although the seeds germinate, striga cannot develop successfully in these roots.
* Intercrop maize with Desmodium or other legumes. Desmodium have been shown to be more effective in reducing striga when interplanted with maize in the field than other legumes such as cowpea, soybean and sun hemp. Desmodium progressively reduces the number of striga seeds in the soil
* Use resistant/tolerant varieties. Some maize varieties show partial resistance, such as "Katumani" in Kenya.

**Qn. Explain push-pull method for control of striga weeds and stem borers in maize production.**

This is a simple effective intercropping strategy where the farmers use Napier grass and desmodium legume as the intercrop.

Desmodium is planted in between the rows of maize.it produces a smell that the stalk borer doesn’t like. The smell pushes away the stalk borer moths away from the maize crop. On the other hand,Nappier grass is planted around the maize crop as a trap crop.Nappier grass is more attractive to the stem borer moths than maize and therefore pulls the to lay eggs on it.but Napier grass does not allow the larvae to develop in it. When the eggs hatch, the small larvae bore into Napier grass stems, the plants produce a sticky substance which traps them and they die of starvation. Hence the maize is saved.

In addition, a ground cover of desmodium interplanted among the maize reduces the striga weeds. Chemicals produced by the roots of desmodium are responsible for suppression of the striga weed.

Benefits

* Increased maize yields
* Increases supply of cattle feed from harvesting the Napier grass and desmodium
* Fixation of N by Desmodium
* Protects the soil from erosion since desmodium acts as s a cover crop
* Increased income fro he sale of desmodium seeds(800shs/Kg)
* Retains soil moisture
* Increased milk production and sale
* Saves on farm labour (no manual removal of the striga)
* Wind break because of the surrounding Napier.

**Harvesting**

Physiological maturity indices

* The leaves and husks start to dry
* The part of the kernel where it is attached to the cob starts to turn brownish or blackish in 90% of the kernels of the cob. This is called black layer/abscission layer.
* The cobs are no longer appreciated for roasting and is not milky
* At least a quarter of the cobs/ears start to droop(face downwards)
* Moisture content falls to 35%
* Calendar method (time taken from planting to maturity) depending on variety and AEZ.

**Method of harvesting**

In Kenya, maize is harvested by hand where the stalks are cut with a panga.some farmer’s stook the maize in the field for further drying.

Reasons for Stooking

* Allows ploughing for the next crop to be done hence making early/timely planting possible.
* Allows the crop to dry further as moisture content falls from 35-20%
* To reduce damages due to lodging, rotting or being eaten by birds and termites
* To keep thieves away

**Drying and shelling**

The drying method depends on environmental conditions and socio economic status. They include sun drying, fire drying, mechanical driers, and solar driers.

Shelling should be done at moisture content of 13%. Its then cleaned by winnowing and treated with insecticide dust at the rate of 50g/90kg bag of maize before storage.

Advantages

* Mixing with insecticides is easier and more efficient
* More accurate application rates of insecticides is attained
* Prolonged shelf life of shelled grains
* Less space is required to store shelled grain
* Easier to control movement and inspect the produce
* Rodents may burrow in the cob

Good storage practices

* Drying grains to bring down moisture to 13% before storage
* Cleaning/fumigating the store before storing fresh produce
* Clearing bushes around the store to keep away rodents
* Good storage hygiene by removing left overs
* Checking and inspecting produce regularly for insect pests, rodents, damaged cobs and rotten grains
* Dusting grains with insecticides
* Storing the sacks off the floor and away from the walls to allow free circulation
* Proper ventilation of the store
* Checking and repairing any leaking roofs.

Post-harvest losses

Account for 15-30% and especially occur during storage

Poor threshing, drying and sorting techniques

Attack by storage insect pests such as rodents, weevils

Growth of moulds/fungi due to improper dying

Rise in heat due to respiration and moisture migration in the store. This may cause moisture condensation in cooler parts of the store and grain masses which then encourages growth of fungi.

**END**

**WHEAT (Triticum aestivum)**

**Introduction**

This is the most important large scale crop in Kenya after maize.Wheat originated from Middle East and was introduced in Africa 20th century. In Kenya it was introduced by Lord Delamare around Njoro area. It is grown in large scale Mau Narok to Narok,Uasin gishu, and Nakuru.

The crop is grown for bread baking and pasta. Residues serve as mulch or used as hay. The by- products are used as animal feed.

**Plant description**

* Wheat is an annual grass which grows to a height of 1-1.5m -. It tillers freely and has leaves with jagged, membranous ligules and short hairy auricles
* The inflorescence is a terminal cylindrical spike and is mainly self-pollinated by wind.
* The fruit is oval with a central groove on the ventral surface and a terminal tuft of hairs. The palea and lemma enclose the fruit. The lemma may be awned or awnless. Seed coat colour ranges from red to white

Physical differences between wheat and barley

* Barley has long beards/awns but wheat has shorter awns.
* Barley has long clasping auricles and leaves are hairless and smooth while wheat has shorter auricles with small hairs
* The glume and palea of barley adhere to each seed and cannot be removed by threshing but in wheat, they are easily removed during threshing to become part of chaff.
* Barley has a finer seed head with a lighter gold colour at harvest time than wheat.
* Barley has 2 rows of grains in each spikelet, one opposite the other while wheat has 3 rows of grain in each spikelet.

**Climatic requirements**

* **Altitude:** Does well at 1800-2900 m AS.L At low altitudes rainfall is low while at high altitude it is humid causing a high incidence of pests and diseases.

Altitude also affects maturity in that a rise or fall in altitude of 300m causes respectively a 15 day lengthening or shortening of the time of maturity.

* **Temperatures:** 24-270C
* **Rainfall:** Wheat is moderate resistant crop but for best yields needs a well distributed supply of soil moisture. In Kenya it is grown in areas that receive 750-1000 mm or more rainfall per year.

During early stages of growth water demand is low but drought at this stage will retard growth permanently.

At 23cm high tillering begins and water demand consequently rises steeply until flowering. Drought at this time restricts the number of tillers, sometimes none develops at all.

Ear initiation occurs towards the end of tillering drought at this stage causes the initiation of few flowers and heads that emerge are short.

At flowering water demand almost levels off and drought soon after cause’s low grade grains which are narrow and misshapen.

At cheese-like stage(when the grains are forming), heavy rains is damaging as it causes; slow grain drying, sprouting (germination of the grain in the head),discoloration or lodging, and may create muddy conditions which prevent combine harvesters working.

Heavy rains when the grains are ripening/drying cause germination of the seeds in the head and discolourationof the grains.

* **Soil requirements**

Wheat does well in a wide range of soils however; ideal soils should be well drained silty loams of reasonable fertility and good lime content at a PH of 6-7.5. Acidic soils produce small wheat grains with a low test weight. Also, aluminium toxicity occurs and this leads plant deficiencies of nutrients such as phosphorus. Sticky poorly aerated soils susceptible to water logging produces poor quality wheat and low yields.

**Varieties**

|  |  |  |
| --- | --- | --- |
| **Low alt(1200-1500m** | **Medium alt (1500-1800)** | **High alt(>1800)** |
| k. fahari | Tembo | Mbuni |
| Ngamia | Kwale | Mwamba |
| Duma | Kifaru | Fahari |
| Chozi | Paka | Kongoni |
|  | Njoro Bw1 | Njoro Bw11 |

The above varieties yield differently though higher altitudes wheat grow slowly and harvested 2-3 weeks later than medium and low altitude wheat. Average yield is 20-32bags/acre depending on soils, climate and seed type. Growing period is 120days for early maturing and 160 days for late maturing varieties.

**Important characteristics to consider when choosing wheat varieties**

* Maturity-early maturing varieties escape damage from hot winds, drought and rusts.
* Disease and pest resistance-against serious pests and diseases such as Hessian fly and wheat rust respectively.
* Resistance to lodging and shattering-since wheat id harvested by a combine harvester, varieties that do not lodge or shatter are the best. The shorter semi dwarf varieties are the best.
* Grain quality-the grain should be of a quality that is required by the millers and bakers to produce quality end products. The classes of whet have different characteristics related to milling, baking or other food use.
* Durum is the hardest of all wheat and provides semolina for spaghetti, macaroni and other pasta products
* Soft red winter (SRW) is high yielding wheat, low protein (10%) and is used for cakes, pastries, flat breads and snack foods.
* Hard white (HW) is for noodles, yeast and flat breads
* Hard red winter (HRW) is the bred wheat having moderate proteins (11-12%).has good milling and baking quality.
* Hard red spring (HRS) is also bread wheat with high protein content (13-14%) with good milling and baking characteristics.

NB; Generally, wheat for bread making should have high gluten content, should be elastic and able to retain co2 during baking giving bread of good structure. For biscuits it should have low protein content and high starch content.

* Acid tolerance-many soils are becoming acidic due to continuous use of DAP and N-fertilizers. Such soils have more AL which can burn root tips. Therefore, a good wheat variety should be tolerant to low soil PH.
* Coleoptile length-many semi dwarf varieties have short coleoptiles which cannot emerge from deep planting. A good variety should have a coleoptile length of more than 3 inches.
* Grazing potential-extra income can be earned from grazing livestock on wheat fields. Awnless varieties are the best for cattle because the awns do not injure livestock during feeding.
* Wide adaptability-a good variety should be able to be grown in wide geographical areas and yield well.

**Field operations**

**1. Land preparation**

Early seedbed preparation immediately after harvesting ensures thorough decomposition of organic matter before sowing. A clean, firm seedbed of fine tilth is required by wheat because its seeds are small and for even rapid germination.

**Burning stubble and straw**

Follows immediately after harvesting in preparation for the next crop. Consideration to burn or not to burn is affected by the following;

* The presence of straw may impede cultivation. True when disc plough are to be because they penetrate slowly when there is much straw on the ground.
* Presence of soil borne diseases; Like Glume blotch and leaf blight that may be carried over to the following season through infected straw if ploughed in. Burning prevents any such carry over.
* Soil structures; farmers who have light Powderly soils with little organic matter sometimes prefer incorporate the straw to improve soil structure.
* The weather; Rain makes burning impossible. In case of any delay until the straw dries out, weeds and volunteer wheat grows amongst the straw preventing efficient burning.
* The speed of straw decomposition; slow or absent in dry soil with low microbial population or at high altitudes where is cool. Presence of un-decomposed straw restricts growth of the following crop. To avoid this farmer may incorporate the straw as early as possible, they may add nitrogen when sowing to compensate for that which is locked up or they may burn the straw.

**Reason for early ploughing**

* Being the slowest operation in mechanical wheat cultivation it should be done early to allow all the land

to ready for sowing at the correct time.

* Allows reasonable time for decomposition of incorporated straw or if grassland is being broken.
* Helps dry out kikuyu grass or couch grass.
* Allows plenty of time to prepare a clean a seedbed by several harrowing. The germinating seed from previous crops are killed by each harrowing.
* If done immediately after harvest of previous crop; the soil is easier to work with because there is usually a little moisture and soil moisture conservation because less moisture is lost from a bare surface than one covered with vegetation
* It’s easier to work the soil because of less moisture before the rains

**Dis advantage**

* Stubble becomes unavailable for grazing.

**2. Planting**

Early planting is recommended at the beginning of the rains to achieve high yields and also for harvesting to coincide with the dry weather. In Rongai (low altitude) planting is done in March-May and harvested in September and October while in Molo (high altitude area) planting is June/July and harvesting in Jan/Feb.

Phosphatic fertilizer is applied at the rate of 50-100kg/ha P2O5 depending on soil types, cropping and fertilization history.

Seed is dressed against soil borne diseases and pests with Copper oxychloride. Carbofuran+Thiram at the rate of 0.85kg/Ha to protect the seeds from fungal soil borne diseases and stem rust. The seeds are obtained from previous crop or buy from dealers in case of new varieties or growing for the first time.

The seed rate is 70-85kg/acre at a spacing of 18cm between the rows and 2.5cm deep. The seed are sown mechanically using drills then followed by rolling to ensure good contact with the soil and for rapid even germination. The disadvantage is that it may encourage soil erosion.

Qualities of good seeds

* True to variety
* High seed purity(freedom from other crop seeds, weeds, foreign materials)
* Should be dense/plump to ensure high germination %
* Larger seeds tiller more than small seeds
* High protein content promotes early seedling vigour
* Should have a higher germination %

**Growth stages of wheat**

Growth and development of wheat are divided into the stages below;

1. Germination leads to seedlings(1st stage)

A wheat seed begins germination by absorbing water and CO2. The embryo/germ gives rise to the radicle (root) and the scutellum (first leaf).the endosperm which contains food supports the germinating seed. The coleoptile (2nd leaf), penetrates the soil and results in emergence of the seedling usually 5-7 days after planting. The first roots on the seedlings are known as primary/seminal roots. They are temporary. Only the main stem has primary roots which are retained throughout life.it also contains secondary/crown roots that arise from underground nodes after the seedling emerges. Many of the stems on the main stems and he tillers are secondary roots. Most roots are found in the top 6 inches of the soil. The extensive distribution of roots throughout the soil and the large root surface area makes the wheat plants efficient and drought tolerant.

1. The growing point and seedling growth

The growing point contains the stem parts-nodes and internodes and wheat head in miniature which later differentiates and the plants begins to joint and eventually heads.

1. Tillering

Tillers are shots that develop from nodal buds on older wheat shoots. The number of tillers depends on seed rate, soil moisture, soil fertility, temperature and variety. The develop soon after the seedling emergences from the soil and have all other growth stages as the main stem. Tillers can be encouraged by fertilizing with N, early planting, low seed rate, and irrigation. Tillers increase yields. Herbicides should not be applied art this stage.

1. Overwintering

Especially when the temperatures are low. When the growing point remains below the soil surface and changes colour white-brown.

1. Jointing

This is the development of nodes and internodes that form the stem of the wheat plant. This begins when the growth of the tillers is complete. This phase marks the change from vegetative growth to reproductive growth. Stage is important for these reasons because growth of the internodes pushes the growing point above the soil. Jointing occurs when the plants have been exposed to winter temperatures otherwise it would continue to produce more leaves. Splitting open the stem during jointing shows the growing point is well differentiated into young head.

1. Booting

During the boot stage, the head is enclosed in the flag leaf sheath at the top of the plant.

1. Heading

At the heading stage, the spike emerges from the boot, within 1-7days after heading, the flowering stage and pollination occurs and the grain begins filling.

1. Flowering

Flowering begins at the center of the spike and progresses towards the end. Appearance of yellow anthers outside of the florets marks the completion of flowering. The actual number of kernels which will form in the spike is determined at this stage.

1. Maturation or development of the grain

Is divided into milk, soft dough, hard dough and physiological maturity, (the stage when kernel weight is maximum). The grain begins growing immediately after flowering and reaches its max size (not weight) in 2weeks. At the first stage, the endosperm has the colour and consistency of milk.as the kernel fills, the endosperm thickens into a soft dough stage and finally a hard dough stage.

1. Ripening-last stage before harvesting where moisture reduction occurs. Ripening includes the changes that occur after the grains reaches physiological maturity. This is characterized by;

* Drop in moisture to 30-35% and later to 12-13%
* Hardened kernels/grains
* Changes in colour of grains
* Senescence and drying of leaves
* Kernels accumulate high dry matter content.

1. Harvesting

Should be done after ripening to reduce loss of yields by lodging, preharvest sprouting and due to birds.

**3. Fertilizer application**

* Nitrogen- is the most limiting nutrient should be applied as pre plant (before planting).rate of application is 75kg/acre or 200kg/Ha. The remaining N is applied during the tillering stage. For maximum economic yields, split applications of N are recommended as follows.40% pre plnat,10% in starter,25% at tillering and 25% at stem elongation. Additional N application of 10-12kg/acre at swollen boot stage affects head fill and grain protein levels.

Roles includes; structural constituent of protein, chlorophyll formation and promotion of vegetative growth.

Excess causes; reduced yields, lush succulent growth causing lodging, delayed maturity, susceptibility to diseases such as rusts & powdery mildew.

* Phosphorus-Rate is 30-40kg/Ha applied as band application during planting. Recommended fertilizers are MAP (11-52-0), DAP (18-46-0) and NPK (23-23-0). Deficiencies cause stunting, pale to reddish leaves, bluish green leaves, and small leaves.
* Potassium at the rate of 20-30kg/acre. Deficiencies cause shortening of the internodes, tips and margins of lower leaves become dry and scotched.
* Copper- Copper is required for grains production and applied at the rate of 0.85kg/ha as seed dressing and another 1.1-1.7kg/ha with herbicide spray during weed control.

Deficiencies cause discoloration of young leaf tips, curling of the leaves, bleached and sterile spikes, on emergence of spikes.

4. **Weeding**

Most common weeds include oat grass, field bind weed, goat grass and mustards.

Weed control measures include;

* Cultural control which includes; preparation of clean seed bed, crop rotation, burning, deep ploughing to burry the weeds, manipulating of planting dates.
* Chemical control; Application too early or late may result in stunting and yield reduction. It is most tolerant when fully tillered but before jointing. No herbicide applied at early boot to soft dough stage. Application would cause sterility, poor grain fill and reduced yields.

**5. Irrigation**

Effects of moisture stress;

* Stunting of the plants
* reduce tillering and
* reduced root development,
* reduced number of spikes and florets
* Curling and rolling of the leaves during midday
* Late booting and sterility of grains
* Reduced yields.

**Harvesting**

* In small scale, it is done with a sickle or a sharp knife but in large scale is done with a combined harvester.
* Wheat matures in 4-7 months depending on variety and altitude. They are harvested using combine harvesters in large scale or by cutting individual heads using knives. Delayed harvesting leads to sprouting of the grain on the ear, rotting and grains are prone to insect damage during storage.
* Once harvested the wheat is cleaned of any foreign matter e.g. weed seed, chaff, and earth particles etc. Then bagged ready for delivery to the buyer.
* They are dried if wet to required moisture content of 13%.
* Lodging hinders harvesting caused by weak straw variety, excessive seed rate, high application of Nitrogen, strong winds and heavy rains in later stages of growth. Use of combines with pick up reels and guards on the cutters bar enable lodged to be harvested but slows the operations. Also lodged plants dry slowly as they are close to the ground, ripen poorly and grains fail to fill out properly. Late lodging leads to production of many tiller late in growth and un even ripening hence unclear sample.
* **Yield**

The average yield is about 1100kg/ha

* **Grading**

Is done based on;

* Moisture content lees than 14%
* Foreign matter less than 2%
* Broken grain less than 2%
* Immature grain less than 2%
* No insects and disease damage
* No germinated seeds
* No mixed seeds.

**Wheat Quality**

* **Baking quality;**

It is the ability of the dough to retain carbon dioxide bubbles and thus to produce a good, light loaf, depends on genetically governed grain characteristics. Gluten, which is a mixture of proteins, determines the baking quality. Strong wheat has a high content of good quality gluten and their dough is able to retain the carbon dioxide bubbles. Weak wheat, on the other hand has insufficient or poor quality gluten.

Bread wheat cultivars in Kenya are categorized into 4 classes depending on the baking characteristics:

* **Group I:** Weak wheat not ideal for baking. Can be used for fodder or blended with superior wheat for baking. These include Kenya Bongo. Kenya Kudu, Kenya Kongoni, Kenya Tumbili Kenya Tausi, Kenya Chiriku and Ngamia.
* **Group II**: Strong stable wheat. Fairly good baking qualities. These include Kenya Mamba, Nyangumi, African Mayo, Kenya Tembo, Nyumba, Popo, Ngiri, Nungu, Kifaru, Mbweha, Kwale and Duma.
* **Group III**: Strong dispensable wheat. Good baking quality. Also used for pasta. Varieties include: Kenya Zabadi, Kiboko, Swara, Paka, Fahari, Kuro, Nyati and Mbega.
* **Group IV**: White wheat used for confectionary and pasta. Good for home baking. Include following varieties: Kenya Kulungu, Nyoka, Leopard as well as Bounty, Mbuni, Pasa,Kenya Paa.
* **Milling quality**

Milling quality depends on whether the endosperm is hard, enabling it to pass through sieves readily, or soft, causing it to block sieves.

**Disease control**

The main components of integrated disease management programme in wheat production include;

* Scouting and monitoring to identify problems early in the season
* Resistant varieties
* Crop rotation
* Crop residue destruction
* Control of volunteer wheat
* Delayed planting
* Balanced fertilization
* Seed treatment before planting
* Use of foliar fungicides
* Bio control
* Use of certified seeds.

**1. Stem rust**

Most important/serious wheat disease cause by the fungus ***Puccinia graminis fsp. Tritici***

Symptoms:

* Pustules (a pimple-like or blister-like structure) containing masses of spores are dark reddish brown and occur on both sides of the leaves, on the stems and on the spikes.
* With light infections the pustules are separate and scattered but coalesce with time.
* Before the spore masses break through the epidermis, the infection sites feel rough to the touch and as they break through the surface tissue takes a ragged and torn appearance.
* Reduced tillering and grain weight and quality.
* The grains may be shrunken to one-half or two-thirds normal size.

Predisposing factors;

Free moisture, rain or dew and moderate temperatures of 200C or more.

Control

* Certified seeds for sowing
* Crop rotation
* Spraying foliar fungicides
* Early planting
* Control of wild grass which may act as alternative host

**2. Glume blotch**

**Caused** by two fungi namely; *Phaeosphaeria (Leptosphaeria) nodorum* and *Septoria tritici*.  
It can cause considerable damage in wet years, especially where wheat has been grown for several years in succession.

**Symptoms** occur at early milk stage through maturity causing infected glumes and awns to develop grey brown blotches starting at the tips of the glumes.Consist of brown lesions on the glumes and around the nodes. At advanced stage of the disease black spots just like dots can been seen on the lesions. These are fungal spore bodies (pycnidia). The affected leaves become shriveled with light brown patches on them. Glume blotch is spread by use of infected seeds, rain splash and infected crop residues.   
**Control:**-Use certified disease-free seeds and seed treatment with fungicides  
-Burn stubble and crop debris after harvest  
-Rotate with non-susceptible crops such fodder grasses or maize

-Avoid excess Nitrogen and also deficiencies

-Use of foliar fungicides before infections

-Use of resistant varieties

**3. Ergot**

**Caused** by the fungus *Claviceps purpurea*. Symptoms; found in all small grain crops especially if sterility occurs for some reasons. Sterile florets open and become susceptible to infection.at flowering, infected florets produce yellowish sticky exudates containing conidia, visible on the glumes. As the spikes mature, kernels of infected florets are replaced by brown to purplish black fungal structures (sclerotia/ergot bodies).

**Control** .same as for glume blotch.

**4. Barley yellow dwarf virus (BYDV)**

**Caused** by Luteovirus  
**Symptoms** include; leaf discolouration from tip to base and from margin to center. The discolouration takes on different colours depending on the plant. In barley, the leaf turns bright yellow; in oat, an orange, red or purple discoloration is seen and in wheat, rye and triticale, the infected leaves are generally yellow and sometimes red. Plants are usually stunted, with a decrease in tiller number and biomass and a weak root system. Suppressed heading, sterility and failure of grains to fill occur in the most severe cases. In the field, symptoms appear usually as yellow or red patches of stunted plants. The disease is most damaging in terms of yield reduction, if it infects a crop at an early stage of growth. The virus is spread by cereal aphids (e.g. *Rhopalosiphum padi, R. maidis,* *Sitobion avenae,* etc.). It is neither seed-borne nor mechanically transmitted. It also attacks maize, rice and several grasses.   
**Control:**   
-Plant resistant varieties, if available  
-Control aphids   
-Control weeds

**5. Take-all disease**

**Caused by (*Gaeumannomyces graminis fsp.tritici)***, a soil-borne fungus.

**Predisposing factors;** neutral to alkaline soils, poorly drained soils, early planting, continuous cropping, volunteer wheat.

**Symptoms**; the fungus invades and blackens the roots, frequently killing them in the process and can easily be uprooted. Affected stems are black and shiny just above the soil level. This symptom can only been seen by peeling away the leaf sheaths. A shiny black discolouration is present under the leaf sheaths at the bases of diseased plants. The disease occurs in slowly widening patches, and in these areas plants with poorly filled or empty ears (whiteheads) may be present. Tillers that emerge are usually sterile and turn white. Premature death of tillers may also be noted. The pathogen survives between crops on cereal roots and stubble. It also attacks barley, oats and rye.  
**Control:**   
-Rotate with non-susceptible crops such as alfalfa, sweet clover or maize for 1-2 years  
-Remove stubble from the fields  
-Avoid continuous cropping with wheat, barley, oats or rye

-control grass weeds

-delayed planting

-seed treatment

**6. Yellow rust**

**Caused** by the fungus *Puccinia striiformis*

The disease is also called stripe rust. Yellow or orange-yellow pustules develop on the glumes or chaff, on the leaves, and on the leaf sheaths. These lesions are arranged in parallel lines along the leaves. The disease may also attack the stems and the kernels. Infected leaves show distinct chlorosis. Damage to the disease is most serious, if plants are attack at milk stage or earlier. Under severe infection kernels may be shriveled. Rapid disease spread is favoured by warm weather with frequent rainfall. Yellow rust also attacks barley, rye, and over 60 species of grasses.

**Control:**

Plant resistant varieties, if available  
Control weeds  
Avoid cropping of wheat in succession

**7. Loose smut of wheat and barley**

**Cause**; The fungus *Ustilago tritici*

**Symptoms;** Are seen at heading time as the diseased heads emerge from the boot. The kernels and glumes have been converted to masses of black spores. These spores are soon blown away, leaving the rachis of the head bare. Heads of infected plants emerge from the boot earlier than normal. Prior to heading, infected plants may have dark green, erect leaves sometimes with chlorotic streaks.

**Pests**

**The Russian Wheat Aphid *(Diuraphis noxia*)**

It is one of the most damaging pests of small grain cereals (e.g. wheat, barley, triticale, rye, and oats) in the world. This aphid is a relatively new pest of wheat in Kenya. It was first identified in farmer’s fields in 1995. It then spread quickly to all the wheat growing areas of the country and it is nowadays the most important pest of wheat and barley. It is also a major pest in South Africa, but has maintained minor pest status in Egypt, Sudan and Ethiopia.

The Russian wheat aphid is pale to light green in colour with an elongated, spindle shaped body and grows to up to two mm long. It has short antennae with rounded very short, nearly invisible cornicles. The feature that easily distinguishes it from other cereal aphids is the presence of an appendage above the cauda, which gives the aphid the appearance of having two tails. They prefer to live in the leaf whorls or in tightly rolled leaves, and thus are partially protected from natural enemies and from contact insecticides. They are hardy and can survive extremely low temperatures. Dry weather favours rapid increase of the aphid.

Unlike many important cereal aphids, the Russian wheat aphid is not a known transmitter of diseases, but causes damage by injecting a toxin into the plants during feeding. This toxin prevents the production of chlorophyll and causes, in susceptible cultivars, leaf chlorosis, longitudinal leaf rolling and white/yellow (warm weather) or purple reddish (cold weather) streaking on the leaves. Extensive chlorosis leads to death of plants while leaf rolling retards plant development causing stunted growth. The tight rolling of flag leaves delays ear emergence, leading to floret sterile heads resulting in reduction of seed set. Aphid infestation also reduces the quality of the seeds produced, as shown by low kernel weight, increased rate of seed deterioration under accelerated ageing conditions, and reduced seedling vigour. The effect of infestation on seed quality is more pronounced under dry conditions. Infestation also may result in reduced seedling vigour.

In Kenya, the damage usually appears when crops have attained the tillering stage. Yield losses ranging from 25 to 90% have been reported.

**Control:**

 Scout your crop regularly. Check for damage signs (first noticeable sign is slight to moderate yellowing of small areas of crop within the field; in addition the crop may appear to be under drought stress, even if there is no drought.)

 Use the correct seed rate to ensure good plant density, as low plant densities are susceptible to heavy attack by the aphid.

 Plant early as possible for your area.

 Provide good growing conditions for the crop. A crop that is not stressed is more tolerant to aphid attack.

 Remove volunteer plants and grasses because they act as the aphid's hosts even before the main crop has been planted.

Use insecticides.

**Assignments**

1. Name two soil and plant factors that affect tillering in wheat (4marks)

2. Importance of early land preparation in wheat production (6marks)

3. Differentiate between wheat and barley (4marks)

4. Discuss stem rust of wheat under the following sub-headings;

(a) Cause

(b) Symptoms and

(c) Control

5. List six criteria that are used in wheat variety selection (6marks)

**END**

**BARLEY (*Hordeum distichum*)**

Barley originated from Ethiopia and south eastern Asia.it is grown in Molo, Mau summit, Londiani, Mau Narok,timau and little is grown in Nakuru and Naivasha.

**Uses:**

* The grain is used in brewing of beer, livestock feed and as an ingredient of baby food in processed food
* It may be cut and hay made while still green
* Baking industry when pearled as a rice substitute.

**Plant description**

Barley is an annual grass which grows to a height of 1m. It tillers freely and has leaves with prominent ligules and large hairless auricles. The inflorescence is a terminal cylindrical spike self pollinated by wind. The grain is pointed at both ends and is united with the awned palea. It has one grain in each spikelet therefore each head has two rows.

Difference between wheat and barley

* Barley has one grain in each spikelet and each head therefore has two rows of grain, one opposite each other. While wheat has three grain in each spikelet and the rows are less obvious.
* Barley seedlings leaves are hairless with smooth auricles while those of wheat have small hairs on their leaves and hairy auricles.
* In commercial barley the glume and the palea adhere to each seed and cannot be removed by threshing: in wheat they are removed during threshing and constitute the chaff.

**Ecological requirements**

* **Rainfall and water requirement**

It should be more than 500mm of rain during the growing period of the crop.

Periods of drought causes premature ripening, thin and steely grains with high nitrogen content, due to insufficient accumulation of carbohydrates in the grain. To produce a plump mealy grain with low nitrogen content the crop must grow steady without check.

* **Altitude and temperature**

Barley does well at 2100m a.s.l below this rainfall is unreliable.

* **Soil requirements**

It requires well drained silty-loams of reasonable fertility and good lime content. Heavy soils seldom produce good barley as the crop is intolerant of water logging.

**Varieties**

* Proctor; is suited to high altitude areas because of its short stiff straws
* Research is suited to low lands
* Midas and imbar

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Variety name/code** | **Year of release** | **Owner(s)** | **Maintainer and seed source** | **Optimal production altitude range (Masl)** | **Duration to maturity (months)** | **Grain yield**  **(t ha-1 )** | **Special attributes** |
| **Tumaini** | **1978** | **EABL/ KARI** | **East African Breweries Ltd and KARI** | **2100-2400** | **4.5** | **4.3** | **Malting** |
| **Bima** | **1984** | **EABL /KARI** | **East African Breweries Ltd and KARI** | **1800-2400** | **4.5** | **3.0** | **Malting**  **Resistant to leaf rust (*Puccinia hordei)*** |
| **Ahadi** | **1989** | **EABL /KARI** | **Kenya Breweries Ltd** | **Above 2400** | **4.5** | **4.6** | **Malting**  **Resistant to scald** |
| **Sabini** | **1993** | **EABL** | **Kenya Breweries Ltd** | **Above 2100** | **4.5** | **3.81** | **Moderately resistant to Scald and leaf rust, Malting** |
| **Ngao** | **1993** | **KBL** | **Kenya Breweries Ltd** | **1500-1800** | **3 - 3.5** | **2-9** | **Early maturity** |
| **Bahati** | **1997** | **EABL /KARI** | **Kenya Breweries Ltd** | 500 - 1800 | **4.5** | **5.1** | **Moderate/good resistance to Scald and leaf rust. Has strong straw, Malting** |
| **Karne** | **2001** | **EABL** | **Kenya Breweries Ltd** | **1800 - 2100** | **4-5** | **4.0** | **Good resistance to BYDV and Scald, Malting** |
| **QUENCH** | **2013** | **SYNGENTA** | **EAML &**  **Syngenta** | **Mau escarpment (Mau Narok, Olkurto, Oloropil and Olchoro) and Upper Eastern (Timau area). {1800-2400}** | **6 Months** | **4-6** | **Resistant to lodging;**  **High malting quality;** |
| **PUBLICAN** | **2013** | **SYNGENTA** | **EAML & Syngenta** | **Mau escarpment (Mau Narok, Olkurto, Oloropil and Olchoro) and Upper Eastern (Timau area). {1800-2400}** | **6-6.5 months** | **6-8** |  **Resistant to lodging;**   **Disease resistant (net & spot blotches)** |
| **GRACE** | **2015** | **EABL** | **UOE/EABL Research and**  **GMS** | **High and Medium altitude regions (1800-2600)** | **5.5 months at high altitude/ 4.5 months at low altitude** | **5-7** | - Large grain size  - **Ear length-long**  - **Ears-drooping**  - Tolerant to net blotch, scald  - Resistant to Lodging.  - Medium maturing  - Better malting/brewing qualities |
| **ALICIANA** | **2015** | **EABL** | **UOE/EABL Research and**  **GMS** | **High and Medium altitude regions (1800-2600)** | **5 months at high altitude / 4.5 months at low altitude** | **4-6** | - Large grain size  - Long ear length  - Drooping ears  - Tolerant to net blotch, scald  - Resistant to lodging |
| **CERISE LAUREL** | **2015** | **EABL** | **UOE/EABL Research** | **Medium and low altitude regions (500-1800)** | **4 months at low altitude** | **4-5** | - Resistant to BYDV, Net blotch and Scald  - Early maturing  - Tolerant to moisture stress |
| **NFC TIPPLE** | **2013** | **SYNGENTA** | **EAML &** | **Mau escarpment** | **6 Months** | **6-8** | Resistant to lodging;  High malting quality; |

**Seed bed preparation and planting**

Early seedbed preparation gives the incorporated organic matter enough time to rot and form humus

It should have a fine tilth and be free from weeds achieved through several ploughing and harrowing operations.

Sowing is done at the beginning of rains using certified seeds give best results.

It is drilled in rows 20cm apart at a depth of 2.5-5cm and at a rate of 60-90kg/ha

**Fertilizer application**

50-60kg/ha of p2o5 used when planting the first crop afterwards 11:54:0 compound fertilizer is applied at the rate of 80-200kg/ha depending on soil fertility.

Copper if deficient is applied at the rate of 2kg/ha of copper oxy-chloride in two splits half as seed dress and the other as foliar spray 5-6 weeks after crop emergence.

**Weeding**

It is done chemically by use of herbicides. It is recommended to use the right concentration and at the right time.

**Harvesting**

Barley matures in 3-6 months depending on altitude and cultivar and is combining harvested. Barley should be harvested at the right time because too early harvesting of barley results to shriveled, steely seeds with high nitrogen content. Therefore the crop should be harvested when completely dry.

**Yields** average 1500kg/ha

**Malting**

Good quality barley is used for making malt which is an essential ingredient of bottled beer. Good quality barley should be plump, uniform, high in quality, low in nitrogen and protein, and bright in colour.

**Procedure of malting;**

To malt, barley is first soaked in water for 2 days and is then spread in a shallow layer in a long box where it germinates for 4 days. The germinated grains are then dried and the shriveled roots are removed by screening. Germination produces enzymes which changes the starch to sugars. During brewing the action of yeast on the sugar produces alcohol.

**Malting quality**

Measured through the following;-

1. **The nitrogen content**

Barley is rejected if it contains over 1.8% nitrogen because it causes a cloudy suspension of proteins in the beer. Ideally it should contain 1.4-1.6% nitrogen

1. **Co-efficiency of mealyness**

When grains are cut in half they should a white mealy endosperm. Mealy grains absorb water quickly and therefore germinate quickly and uniformly. Hard and steely grains germinate slowly and unevenly and tend to have higher nitrogen content. Therefore a sample that has 50% or more mealy grains is acceptable over 80% is ideal.

1. **Germination %**

95% or more is acceptable

1. **Size**

It should be plump and well filled; this ensures that it is mature and will germinate well. Thin barley which passes through a 2.4mm screen is rejected.

1. **Moisture content**

It must be 14% or lower so that the barley can be stored safely.

**Others**

* Must not be discolored this would causes moulds and poor germination.
* Should not be damaged by weevils or improperly set combine harvesters as it results to poor germination
* Different varieties should not be mixed because they have different germination characteristics.
* The grain should have fine wrinkled husks a sign of well filled mature grain; coarse wrinkled skin may be caused by premature ripening and is disliked by the maltsters.

**END**

**RICE (Oryza sativa)**

Rice originated from south eastern Asia and spread to the other parts of the world. Rice is [Kenya’s](http://softkenya.com/) third staple [food](http://softkenya.com/food) after maize and wheat. Rice Farming in Kenya is estimated at between 33,000 and 50,000 metric tonnes, while consumption is between 180,000 and 250,000 tonnes. About 95% of rice in Kenya is grown under [irrigation](http://softkenya.com/farming/irrigation-in-kenya/) in paddy schemes managed by the National Irrigation Board (NIB). The remaining five per cent is rain fed. (Upland rice)

The crop is grown mainly for its grain which may be prepared and consumed in various ways by man and livestock. It is grown mainly in Mwea, Bunyala Ahero, Mbalambala and in Kano plains.

**Plant description**

-Rice is an annual plant which may grow to a height of 0.5-1.5m depending on the variety.

-The roots have specialized tissues, the aerenchyma enabling the crop to grow under low oxygen concentrations. -The plant tillers freely and has leaves with triangular and membranous ligules.

-The leaves may have or not have auricles and are triangular in shape.

-the plant tillers (production of shoots)

-The inflorescence is an open panicle and self- pollinating crop. It takes average of 30days from flowering to ripening.

-The shape of the fruit varies with cultivars, directly sown rice takes 3-4 months while transplanted rice takes 2-3 weeks longer.

-The husked rice grain is white and translucent; some cultivars may be red, brown and blackish.

-98-99% of all rice varieties are self- pollinated

**Ecological requirement**

* **Altitude**

Rice does well below 1200m a.s.l where mean annual temperature is 20-300c, those that mature in cold period yield poorly.

* **Sunlight**

Rice flowers when day length decreases. Towards the last 45 days in the field there should be sufficient sunlight to enhance proper fertilization and grain filling.

* **Rainfall**

Rice grows in water logged conditions and also in standing water to suppress weeds. It’s capable of transporting oxygen from the leaves to the submerged roots.

Heavy rains at flowering stage discourage seed setting.

Paddy rice requires 1500-2000mm of rainfall per season while for upland rice requires 750mm of rains well distributed throughout the growing season. Heavy rains discourage seed setting causing annual variation in mwea.

* **Soils**

The best soils are heavy alluvial soils commonly found in river beds and river deltas as they can retain water for a long time at a PH range of between 5.5-6.5.

**Cultivars**

We have

Sindano;-commonly grown in Kenya especially under irrigation.

Basmati 217 (pishori); yield per unit area is very low but quality is very high.

**Others are**; IRR1 from Philippines

IR1, IR22, IR8, IR227 they have advantages over others like;

* High yielding
* Produces high quality grains
* Resistant to blast disease
* They are short and therefore not susceptible to logging.

**Land preparation**

The land is cleared previous vegetation either manually or by hand. Trash is burned if any to reduce incidence of blast disease and leaf rust. Also to discourage the formation of good soil structure so as to encourage good water holding capacity.

The land is portioned into smaller plots by erecting banks (bunds or ridges). The plots are then flooded with water up to a depth of 7.5-10cm. a few days later they are cultivated either by jembe, ox plough, or rotary cultivator. Finally leveling is done by hand to ensure even distribution of water in the plots. After which the nursery is made.

**Planting**

* **Direct seeding**

The seeds are broadcasted before onset of rains at a rate of 110kg/ha. Use of pre-germinated seeds gives good results in well managed, leveled field and can survive some degree of flooding. Early flooding is discouraged in un-germinated field it should be delayed to enable the seed get oxygen needed for germination. Then after germination water level should be carefully managed as the seedling are small and may be submerged in water and die. Also the field should be well leveled and weeds controlled for better yields.

* **Use of transplants**

**Nursery operations;**

Used for paddy rice. The seeds are soaked in warm water for 24hrs and kept moist. Seeds are put together for further 24-48hrs until germination is observed by emergency of the radical. It is then that seeds are broadcasted evenly in a well prepared nursery and are covered with fine soil. Seeds take one month (3-4weeks) to be transplanted when they are 15cm high.

The seed rate is 44-45kg/Ha or 18kg/acre of seeds are planted in a nursery measuring 18.5m by 18.5m which is enough for 1Ha.

Water is drained from the nursery to leave a thin film of water immediately before sowing. Nitrogen fertilizer (as Ammonium Sulphate) at the rate of 80-110kg/Ha is applied. Seeds are broadcasted in the mud. The main aim of the nursery is to grow healthy seedlings as soon as possible.

**Advantages of planting in nursery compared to direct planting**

* Easy to manage seedlings in a nursery.
* Easy to control water level in a nursery than in the field.
* Transplanted seedlings take a shorter time to mature compared to those direct planted.
* It is impossible to direct plant the seeds in the water soaked soil while maintaining the correct spacing.

**Transplanting**

Before transplanting the water is drained from the field immediately before transplanting to leave wet mud or thin film of water. The super phosphate fertilizer (56kg P205/Ha) and 15KgN/Ha is distributed evenly on the seedbed before transplanting, and then it is flooded with water afterwards. Another 15KgN is broadcasted 3-4 weeks later. Different rice varieties differ in the spacing depending on tillering ability. Too wide spacing encourages prolonged periods of tillering which also causes prolonged ripening which pose difficulties during harvesting.

**Spacing**

10cm by 10cm or 20cm by 20cm is adopted depending on the cultivar tillering capacity. Wider spacing encourages prolonged period of tillering formation, pronged ripening period hence harvesting problem.

**Water management/control**

**Qn. Explain water level management in rice production after transplanting to harvested. (7marks)**

* 3-7 days after transplanting, the water level should be increased to 10cm until the rice starts to tiller.
* When the rice starts tillering, the water level should be reduced to 3cm and maintained at that level during the tillering stage.
* When the rice starts flowering(booting stage),the water level is increased to 5-6cm and maintained at that level until the grains starts forming
* During grain formation (heading) the water level is further increased to 10cm and maintained until grains mature well.
* When the grains are fully mature, the water level is gradually reduced such that there will be no water in the field 2weeks before harvesting.

As rice grows level of water is increased such that a third of the plant is submerged. Water should be warm as cold water results to empty heads.

Freshness of water is maintained by either ensuring that the water flows very slowly but continuously through the plots or by changing the standing water in the plots every 2-3 weeks.

Three weeks before harvesting the field should be drained to enhance drying usually when 50% of the heads have started bending over because small lumps of clay can contaminate the final product.

Objectives of flooding rice fields

1. To control weeds by suppressing them
2. To prevent loss of Nitrogen released by decomposing organic matter through the process of denitification.
3. Ammonia released during decomposition of microorganisms is conserved since it’s not converted to nitrates.
4. To save the seedlings from the effects of high concentration of toxic substances generated by decomposition. Some of them are leached.
5. Increase the humidity in the environment which is required during pollination and fertilization.

**Fertilizer application**

In the nursery 25kg of sulphate of ammonia is broadcasted because of its solubility.

In the seedbed double super phosphate is broadcasted after ploughing at the rate of 120kg/ha.

They are top dressed with sulphate of ammonia at the rate of 250kg/ha through split application. The first split is usually applied two weeks after transplanting and the second split is applied 40 days later.

**Weed control**

It is not a major issue in rice production but where problematic they can be controlled chemically by use of 2,4-D and MCPA. They can also be uprooted manually by hand. Types of weeds common in rice fields are grasses (paspalum), sedges (purple/yellow nut), and broad leaved weeds (Commelina benghalensis)

**Harvesting**

It takes 130-150 days to mature depending on cultivar and altitude. Harvesting is done by use of sickles whereby the stems are cut and heaped into bundles and left to dry in the field to ease threshing.

Threshing is done manually by hitting the heads of rice on a flat surface. Seeds are then winnowed to remove the chaff. The rice grains are then dried to a moisture content of 13% ideal for milling, bagged and dispatched to various stores for milling.

Yields 1100-1700kg/ha of direct sown rice

**Milling**

It is done to remove lemma and palea which adheres closely to the grain. The embryo is removed which contain more proteins minerals, fats and vitamins.

**Parboiling**

It involves soaking the paddy (harvested grains before they have been separated from their husks by milling) in hot water and then steaming it before milling. The main purpose of parboiling is to avoid removal of soluble B-vitamins and minerals during milling. Steaming in warm water causes these soluble substances to move to the inner layers of the endosperm hence retained.

**Importance;**

* To harden the grain and reduce milling loses through breakages.
* Resulting rice is less sticky when cooking.
* Retain nutrients as water soluble vitamins are transferred from the outer layer of the endosperm to the inner part therefore retained during milling.
* Resulting rice has a greater nutritive value.

**Pests**

1. **Hispid beetles (*Trichispa sericea*)**

Hispid beetles are serious pests of rice in some countries in Africa, causing severe defoliation and as vectors of the Rice Yellow Mottle Virus. Adult beetles have numerous spines on thorax and abdomen. Trichispa sericea is the most common of the hispid beetles. The adult is a dark grey beetle covered with spines, and about 3 to 4 mm long. Females lay eggs singly in slits made under the epidermis of the upper portion of the leaf. Eggs are white, boat-shaped and about one mm long. Upon hatching, the grubs (larvae) mine within the leaf. Grubs are slender, yellow and about six mm long. They pupate in the mine. When infested leaves are held against the light, the grub or pupa may be seen as a dark spot in the mine. Hispid beetles attack the crop in the early growth stages. Larval feeding occurs during the tillering stage. The first attack in a field is highly localised, but the infested area spreads rapidly.   
  
Feeding by adults on the leaves causes characteristic narrow white streaks or feeding scars that run along the long axis of the leaf. Mining by grubs within the leaf shows as irregular pale brown blister-like patches. Feeding results in loss of chlorophyll and the plants wither and die. The most serious damage occurs in nurseries, which may be completely destroyed. Severe infestations sporadically occur on transplanted rice and can kill the plant. When the plants survive, they usually recuperate and produce some grain. However, damaged plants often mature late. Hispid beetles are prevalent in wetland environments, especially irrigated lowland fields. They are generally most abundant during the rainy season.

**Control;**

* Use close spacing. Populations of adult hispid (T. sericea) are affected by the spacing of transplanted seedlings. Studies in West Africa have shown that population of this hispid beetle were higher in close spacing of 10 x 10 cm than in wider spacing of 20 x 20cm (WARDA).
* Keep bunds and surroundings free of grass weeds.
* Destroy stubbles and avoid ratooning.
* Ensure balanced nutrition. Avoid excessive nitrogen application.
* Spraying with insecticides

1. **Stem borers: Spotted stem borer (*Chilo partellus*)**

Several species of stem borers attack rice. The more important are the striped borer (*Chilo partellus*), Chilo zacconius, Chilo orichalcocilielus, the white rice borer (Maliarpha separatella), the yellow borer (Scirpophaga sp.) and the pink stem borer (*Sesamia calamistis*).   
The caterpillars bore into the stem of rice plants. Caterpillars of the yellow borer bore into the stem below the growing point, destroying tillers. The white borer and the pink stem borer attack rice at full tillering stage preventing grains from filling up and ripening. This damage results in empty panicles known as "whiteheads". The striped borer feeding on rice plants at all stages. Young caterpillars cause "dead hearts".

**Control:**

* Practice field sanitation. Burn or feed debris to livestock after harvest.
* Plough and flood after harvest. These practices destroy diapausing stem borer caterpillars
* Practice early and synchronized planting. Synchronized planting over a large area allows the most susceptible stage of rice to escape from stem borer damage.
* Practice proper water management
* Conserve natural enemies. Wasps that parasitize eggs and caterpillars, and predators such as ants, dragonflies, assassin bugs, carabid beetles and spiders are important natural enemies of stem borers.
* The following cultivars are reported to be resistant to stem borers: Oryza sativa japonica sub-species: "LAC 23", "ITA 121", "TOS 4153", and upland "NERICA"s ("NERICA 1", "NERICA 2", "NERICA 4", "NERICA 5", and "NERICA 7") (WARDA).
* Timely spraying.

1. **Sudan dioch (*Quelea spp)***

They feed on ripening seeds

**Control:**

* Scaring/physical control or use of scare crows
* Destroying their breeding sites by using explosives

**Diseases**

1. **Rice Blast caused by the fungus *(Pyricularia oryzae*)**

**Symptoms**: This disease can cause serious losses to susceptible varieties during periods of blast favourable weather. Depending on the part of the plant affected, the disease is often called leaf blast, rotten neck, or panicle blast. The fungus produces spots or lesions on leaves, nodes, panicles, and collar of the flag leaves. Leaf lesions range from somewhat diamond-shaped to elongated with tapered, pointed ends. The center of the spot is usually grey and the margin brown or reddish-brown. Both the shape and colour of the spots may vary and resemble those of the brown leaf spot disease. Blast differs from brown leaf spot in that it causes longer lesions and develops more rapidly.   
  
The blast fungus frequently attacks the node at the base of the panicle and the branches of the panicle. If the panicle is attacked early in its development, the grain on the lower portion of the panicle may be blank giving the head a bleached whitish colour, giving the name "blasted" head or rice "blast". If the node at the base of the panicle is infected, the panicle breaks causing the "rotten neck" condition. In addition, the fungus may also attack the nodes or joints of the stem. When a node is infected, the sheath tissue rots and the part of the stem above the point of infection often is killed. In some cases, the node is weakened to the extent that the stem will break causing extensive lodging. Blast generally occurs scattered throughout a field rather than in a localized area of the field. Late planting, frequent showers, overcast skies, and warm weather favour development of blast. Spores of the fungus are produced in great abundance on blast lesions and can become airborne, disseminating the fungus a considerable distance. High nitrogen fertilization should be avoided in areas that have a history of blast.

**Control:**

* Plant early.
* Avoid excessive or high levels of nitrogen.
* Proper flood management.
* Plant resistant varieties (e.g. "Nerica". This is the most effective method of controlling rice blast.
* Fungicide application.

1. **Rice Yellow Mottle Virus (RYMV)**

Rice yellow mottle virus is endemic in Africa, was first reported in Kenya in 1966, but is now known to occur in almost all irrigated rice growing areas in Africa. This disease can cause up to 92% yield loss on "super", the most popular rice variety in Tanzania.  
  
RYMV causes severe infections mainly in irrigated rice and is transmitted by beetles (Sesselia pusilla, Chaetocnema pulla, Trichispa sericea and Dicladispa viridicyanea) and mechanically. It is not seed transmitted.   
  
Major symptoms of the disease are yellowing of leaves, stunting of affected plants, reduced tillering of the affected plants and sterility of the seed/grain.

**Control:**

* Plant resistant varieties. The following cultivars are reported as resistant to RYMV: Oryza sativa japonica sub-species: 'LAC 23', 'Moroberekan', 'IR 47686-1-1' for direct seeded rainfed lowlands, and Oryza sativa indica sub-species: "WITA 9", "WITA 11" and "Gigante" (tete) for irrigated lowlands (WARDA).
* Avoid / minimise mechanical injuries.
* Avoid exposing healthy seedlings and plants to virus contaminated and infected material (water, soil, cattle faeces and plants).
* Control insect vectors (see above under pests Hispid beetle and Flea beetle)
* Transplant early before the outbreak of Hispid beetles occur. *Trichispa sericea,* with reduction in spacing of plants.
* Destroy crop residues after harvest and ratoons that harbour the virus and insect vectors.
* Synchronous planting. Wide range and non-synchronous planting dates increases the risks of RYMV outbreaks.
* Plant diverse varieties on a single plot
* Change of site for nurseries.
* Rough infected plants.
* Reduce fertilizer application on attacked plots.
* Weed timely. Early and double weeding helps reduce the weed reservoir of the virus and insect vectors.
* Withhold irrigation water between plantings to provide a rice free period and so restrict the build-up of the virus and insect population.

1. **Damping-off diseases**

Failure of seedlings to emerge is the most obvious symptom of seed rot and pre-emergence damping off. Examination may reveal a cottony growth of mycelium (mould) in and around seed coats and the emerging seedlings, indicating attack by water mould(s). The growing point or root of germinated seedlings has a dark brown discolouration or rot. The base of the leaf sheath and the roots of emerged seedlings have a similar dark brown or reddish-brown rot. Affected seedlings appear stunted and yellow and may soon wither and die (seedling blight). Water moulds are particularly severe in water-seeded rice culture. In areas where fields are frequently water-seeded, it has become difficult to obtain adequately dense and uniform stands. Seed rots caused by the water moulds Pythium and Achlya, and to a lesser extent by the fungus Fusarium, have been identified as the causes of the problem. These fungi often act as a complex within affected fields.   
  
Symptoms of water mould can be observed through the flood water as balls of fungal strands radiating from seeds on the soil surface. When the flood is removed using the critical point method of water-seeding, affected seeds are surrounded by a mass of fungal strands. This results in circular, copper brown or dark green spots on the soil surface, about the size of a quarter, with the rotted seed at the centre. The colours of the spots are the result of bacterial and algal growth. Seed rot by water moulds is favoured when the water temperature is unusually high or low. If seedlings are attacked after germination at pegging, seedlings become yellow and stunted and grow poorly.

**Control:**

* Use certified disease-free seeds for planting

**END**

**Sorghum (*Sorgum bicolar)***

Sorghum originated from Ethiopia and was introduced to east Africa before 100 A.D. Sorghum is the fifth most important cereal crop and is the dietary staple of more than 500 million people in 30 countries. It is grown on 40 million ha in 105 countries of Africa, Asia, Oceania and the Americas. The USA, India, México, Nigeria, Sudan and Ethiopia are the major producers. Other sorghum producing countries include Australia, Brazil, Argentina, China, Burkina Faso, Mali, Egypt, Niger, Tanzania, Chad and Cameroon. Grain is mostly used as food (55%), in the form of flat breads and porridges (thick or thin) in Asia and Africa, and as feed (33%) in the Americas. Its Stover is an increasingly important source of dry season fodder for livestock, especially in Asia.

Sorghum farming in [Kenya](http://softkenya.com/) is an important agricultural activity in the economy. Sorghum is grown in western, northern [Rift Valley](http://softkenya.com/kenya/rift-valley-in-kenya/), eastern and some parts of Central Province.

**Advantages of sorghum over other cereals;**

* Is drought resistant and yields well in the drier parts of E. Africa.
* Tolerates water logging/poorly drained soils
* Yields reasonably well in poor infertile soils
* Adapted well in wide AEZs
* Can be ratooned from season to season (without planting seeds each season).
* Recommended for the sick e.g. Diabetic persons, aged persons etc.
* Tolerant to soil salinity and alkaline soils
* Has a more efficient type of photosynthesis(C-4)hence suitable to tropical environment.

Disadvantages

* Sorghum varieties have lower yielding potential than maize in areas of good/moderate rainfall
* Is heavily attacked by birds than maize
* Harvesting, threshing and cleaning exercise is laborious
* Not preferred by consumers compared to maize.

The crop is fairly drought resistant and thus it is quite popular in drier areas of the Kenya.

**Uses**

* Grown for its grain which can be consumed in diverse ways by man and livestock.
* Stems and leaves may be utilized as forage and silage feed for livestock.
* The stalks are used for thatching huts (roofing).
* Stovers can be used as source of fuel(firewood)
* The grains are fermented and used to make local brew.

**Plant description**

Sorghum is a vigorous grass which grows to a height of 0.5-6m with a very efficient, well branched root system thus a drought resistant crop. The roots are found within the top 1m of soil.

It may or may not produce tillers depending on the cultivar.

The endodermis contains considerable amounts of silica which may prevent its roots from collapsing in dry soil.

The inflorescence is a panicle borne at the terminal end of which may be open or compact; they may be erect or goose necked. The glumes may be large or small with or without awns. The seed coat may be easily removed by pounding or persistent; it may be white or almost any shade of brown or red and the endosperm may be flinty or mealy.

Sorghum is self-pollinated and a ratoon crop.

**Ecological requirements**

* **Rainfall and water requirements**;

It is drought resistant crop because of its dense and well developed rooting system. Also it can reduce its transpiration during period of water shortages by rolling its leaves, stomata closure in this way it will remain dormant. It also has waxy leaf covering.

Sorghum needs a rainfall of at least 300-380mm during its growing period. It withstands short periods of water logging.

* **Altitude and temperature**

Sorghum prefers warm conditions of 300C, and grows at an altitude of below 1500m a.s.l above this they are affected by disease as downy mildew , attacked by pests such shoot fly and poor yields.

* **Soil requirements**

It grows best in well drained fertile soils.

**Varieties**

We have; Brown or red varieties have persistent testa, are bitter and best for brewing.

White varieties have a non-persistent testa and are more palatable.

These varieties perform well at altitudes between 0 and 2300 m above sea level.

|  |  |  |  |
| --- | --- | --- | --- |
| **VARIETY** | **AVAREGE**  **YIELD/Acre.**  **(90kg)** | **PERIOD TO**  **MATURITY**  **(MONTHS)** | **SPEACIAL ATTRIBUTES** |
| **SERENA** | 12 | 3-4 | * It is a brown seeded variety * It has a long stem and good root system * Fairly tolerant to striga, rust, leaf blight and grey leaf spot. * Performs well in the moist mid altitude region and the semi-arid lowland. * is as a result of crossing Dobbs and a variety from Swaziland |
| **SEREDO** | 12 | 3-4 | * It is a brown seeded variety * It is taller than Serena with good tolerance to lodging * Its head is conical and semi compact in shape with brown grain which are slight bigger than those of Serena * Perform well in moist altitude and the semi-arid lowlands * It is widely adaptable |
| **GADAM** | 8 | 3 | * It is grayish in colour * Tolerant to bird infest ion ,stem bores, shoot fly and foliar diseases * Has excellent malting qualities * performs well in the coastal strip arid lowland |
| **E 1291** | 15-20 | 5 | * it is brown in colour * dual purposes varieties with good beverage  perform well in the cool semi-arid highland of Nakuru ,Baringo,Laikipia,Naivasha,Narok,Trans nzoia,Uasin Gishu,Kuria,Kericho,Trans Mara, Parts of Koibatek and Taita Taveta. |
| **Dobbs** |  | 4 | * Good recovery after attack by shootfly * High yielder * More palatable |
| **E 6518** |  | 8 | * Brown seeded variety |
| **KARI/MTAMA** |  | 3-3.5 | * Brown seeded variety |
| **Namatare** |  |  | * from Buganda * is used for making beer * can be ratooned repeatedly |

**Field establishment**

Early seedbed preparation usually results to high yields. It requires a seedbed of fine tilth since the seeds are fairly small. During this period weeds especially grass weeds should be eradicated

**Planting**

The seeds should be dressed with copper.

The crop may be broadcasted or sown in rows. When sown at a spacing of 65cm by 15cm at the highlands and 90 by 15 cm in dry lands. The seed rate of 7-10kg/ha and at a depth of 2.5-5.0cm, three seeds are always planted per hole.

**Field maintenance/management**

**Fertilizer application**

It is recommended to apply 20-40kg/ha P2O5 at planting, 20kgN/ha as a top dress 3 weeks after planting.

The Small scale holders rarely hold this recommendation. Manure at the rate of 10T/Ha before sowing. C.A.N should be applied as top dress 3 weeks after sowing to boost vegetative growth.

**Weeding**

Important at the early growth stages of sorghum

Where the crop is broadcast they are normally uprooted while in rows they are controlled by use of hoes, jembes and pangas.

Use of herbicides for broad-leaved and grass weeds like striga is practiced.

**Thinning**

This is done when the crop is 25cm tall and two vigorously growing seedlings are left in each hole.

**Harvesting**

They mature in between 2.5-8 months depending on varieties and altitudes.

They are harvested by breaking off the heads by hands, then sundried.

The grains are detached from the heads during threshing, winnowed and finally dried to moisture content of 10-11% before storage.

Yields range from 550-1700kg/ha. Under good husbandry, yields up to 3400-4500kg/ha. Sorghum can be ratooned for one or two seasons.

**Ratooning**

A ratoon is a crop that emerges or develops after a previous crop has been harvested. The stem and root primordia of the rootstock will develop when ecological conditions are favourable to give rise to a ratoon crop.

Advantages

* Economical. No need for replanting each season hence reduced cost of production.
* Agronomically,the crop is already established and will make use of most of the available moisture and shoot tillers easily
* The crop can better withstand drought and other adverse conditions
* A ratoon crop yields better than local varieties because of better nutrient usage.

Disadvantages

-Spread of pests and diseases from season to season.

-Hybrids such as serena and seredo do not tiller well compared to the local varieties. Hence low yields.

**Marketing**

The crop is marketed through the National Cereals and Produce Board. Private buyers also purchase sorghum directly from farmers.

**Pests**

1. **Bird**s –Sudan dioch (*Quelea quela aethopica*). They are the major causes of crop loss in sorghums they feed on ripening grains.

**Control**;

* Growing of resistance varieties like those that are bitter tasting seed coat, goose necked, brown grained varieties, varieties with large glumes etc.
* The Ministry of Agriculture has a quelea control unit, which kills large numbers of birds using ﬂame throwers, explosives or poison sprays in their breeding colonies.
* Use of scare crows or physical methods e.g sound to scare them away

1. **Sorghum shoot fly (*Antherigona varia*)**-

The adult ﬂy lays eggs on the underside of very young plants. After hatching, the young larvae enter the funnel and moves down to feed on the young stem, killing the young shoot i.e attacks the plant during the early stages of growth damage.

The central shoots become yellow and then die. Plant responds by producing several tillers.

**Control**

* Use of resistant varieties
* Early planting
* Chemically by use of six endosulfan sprays at intervals of three days.
* Having a closed season.

1. **Stem borers- *Busseola fusca***

Feeds on funnel and developing tissues

**Control**

* By use of insecticides
* Refer to pests of maize

1. **Sorghum midge *contarina sorghicola***

Cause grain hollowing

**Diseases**

Several fungal diseases affect this crop they include; leaf blight (Helminthosporium spp), anthracnose (*Colletotrichum graminilola*), smuts (*Sphacelotheca spp*)

They affect the leaves while the smut affects the inflorescence.

* They are controlled by planting resistant varieties and seed dressing.

**END**

**FINGER MILLET (*Eleusine coracana*)**

This is the third most important food crop after maize and sorghum especially in western Kenya. The crop originated in Africa but was first cultivated in Ethiopia.it can grow in diverse environments ranging from 300m ASL and in less fertile soils and black cotton soils where other crops would do poorly. Most of the finger millet is produced in western and Nyanza Kenya around Busia,Bungoma,Kakamega and Rift valley.

**Advantages over other cereals**

* Can be stored for longer periods without use of insecticides than other cereals
* Less pest problems attributed to the small size of the seeds. difficult for the pest to live in them
* The seeds take shorter periods to dry to the required moisture levels
* Lower sugar levels hence nutrionally recommended for diabetic persons.
* Used as a food security crop in shortages of maize.
* Superior to maize, sorghum and rice due to high levels of Iron and calcium. Hence highly recommended for special groups of the population. E.g. Infants, elderly etc.

**Plant characteristics**

-Plant rarely grows taller than 1.2m in height

-Tillers freely and has narrow grass like leaves.

-Have 6 spikes about 10cm long which are digitally arranged giving the crop name finger millet

-Self pollinated

-Tolerates drought in early stages of growth

-yields well on infertile soils

**Varieties**

Katumani Fm-1 for the highlands

Lanet Fm-1

Gulu

Poso millet-for medium potential areas e.g. Embu, Meru and R.valley

P224 (fox tail millet)-for coast region

Two varieties (Gulu and P224) are highly recommended for the following reasons;

* Early maturing i.e. 3 months
* Less susceptible to finger millet blast disease
* Easy to harvest since they are not too tall
* Uniform maturity of the heads
* High yielding
* Easy to thresh using less energy.

**Field establishment and management**

A fine seed bed is required due to the small size of the seed for better germination% and establishment. Proper land preparation is necessary to produce a clean seedbed free of perennial weeds. The seeds are usually broadcasted at the beginning of the rains. However, some farmers drill the seeds uniformly in shallow furrows at 30cm apart.

Thinning is done 4weeks after emergence to leave one seedling every 15cm interval along the furrow.

First weeding should be done 2 weeks after germination and repeated 2 weeks later.

A 100kg bag of the Compound fertilizer 20:20:0 is applied during planting. Also 10T of manure should be incorporated before sowing. The crop is not usually top dressed.

**Harvesting**

The crop should be harvested as soon as the seeds are hard to avoid loss of grain through birds feeding. A sickle is used to cut the heads and is later dried to 13% moisture level before e threshing and winnowing.

**Challenges of production among the farmers**

* Lack of certified/improved seeds. Less research on the crop improvement
* Lack of market and low prices per kg
* Most farmers do not apply fertilizers and manure hence low yields
* Poor weeding practices
* Poor planting methods and land preparation.

**End**

**2. ROOTS AND TUBERS CROPS**

**CASSAVA (*Manihot esculenta*)**

Order; ***Euphorbiales: Family; Euphorbiaceae***

Cassava is native of Latin America and was introduced to the African continent by Portuguese traders in the late 16th century.

It is important food security root crop because:

* it is drought resistant,
* It requires few production skills or inputs.
* has ability to give good yields on poor soils,
* resistance to pests (especially locust)
* Has ability to remain in soil as famine resistant
* Requires little labor
* Source of carbohydrate
* Used in making livestock feeds
* There are no labour peaks because the necessary operations in its production can be spread throughout the year, and
* Its yields fluctuate less than those of cereals.

**Limitations**

* Its gynogenic glycoside content can lead to hydrocyanic poisoning unless precautions are taken during preparation of tubers like proper peeling/soaking in water/fermenting/drying/cooking.
* Poor nutritive value as it contains mainly starch and fiber
* Low yield potential at altitudes above 1500m ASL

**Plant characteristics**

-They are swollen lateral roots which are cylindrical and un-branched numbering 5-10 per plant and measuring up to 15cm in diameter and up to 0.9m in length.

-The stems are woody and much branched growing to a height of 4.5m.

-Flowers and seeds are produced but not used for field planting (propagated vegetatively).

**Ecological requirements**

* **Rainfall and water requirement**

Drought resistant crop growing where rainfall is low and unreliable. In dry periods many leaves are shed thus reducing transpiration and water requirement.

Does not do well in areas with bimodal rainfall because rains are too short to allow satisfactory tuber expansion eg. Eastern and coastal areas.

* **Altitude and temperature**

Needs warm areas at an altitude below 1500m but is occasionally found at higher altitude like central province and kisii highlands where they are grown on the edge of terraces or on wash stops in gullies or water cause to prevent them from eroding

* **Soil requirements**

Best growth and yield are obtained on fertile sandy loams. Cassava is able to produce reasonable yields on severely depleted or even eroded soils where other crops fail. Gravelly or stony soils cause problems with root penetration and are unsuitable, as is heavy clay or other poorly drained soils.   
Cassava growth and yield are reduced drastically on saline soils and on alkaline soils with a pH above 8.0. The optimum pH is between 5.5 and 7.5, but cultivars are available that tolerate a pH as low as 4.6 or as high as 8.0. Reasonably salt-tolerant cultivars have also been selected. Very fertile soils encourage excessive foliage growth at the expense of storage roots.

**Varieties**

A number of both local and improved varieties exist in Kenya:

Vircra is resistant to viral diseases, high yielding (30-40t/ha/yr.),

|  |  |  |
| --- | --- | --- |
| 1. Coast region |  |  |
| a.) Local types | I | Kibanda meno - very sweet |
|  | II | Katsunga - leaves taste like wild lettuce when cooked |
| b) Improved types | I | Kaleso (46106/27) - high yielding, for human consumption |
|  | II | Guso - Better yielder than Kaleso. Also for human consumption |
|  | III | 5543/156 - It is a high yielding variety for livestock. It is bitter. |
| 2. Eastern Region Katumani | I | KME - Sweet, less fibrous and has low cyanide content |
|  | II | KME 61 - Bitter and more fibrous than KME |
| 3. Western Kenya | I | 2200, Tereka, Serere, Adhiambo lera, CKI, TMS 60142, BAO |
|  |  |  |

**Land preparation and planting**

Usually grown in a rotation normally on the flat seedbed but establishment on ridges is highly recommended**.**

It is vegetatively propagated by use of stem cuttings/setts**.** The cuttings should be selected from disease free plants to avoid transmission of diseases.

Ideal stem cuttings should be 30-45cm long and 2.5-4.0 cm thick

The cuttings should also contain at least two buds and a single leaf to speed up the germination rate

They are planted at an angle of 450 or less at least half buried in the soil and the buds facing upwards. The cutting should be from hard wood stem of mature plants

Spacing in pure stand is 1.5m -0.9m

Cuttings usually sprout from 7-14 days from planting

**Field maintenance**

**Weeding**

Weeding is necessary every 3-4 weeks until 2-3 months after planting. Afterwards the canopy may cover the soil and weeding is less necessary.

**Fertilizers**

Potash is essential for good yields 10:10:20 NPK mixture on acid sandy soils sulphate of potash are also used

**Harvesting**

Take 9-18 months to mature according to variety they can be harvested either piecemeal or by uprooting the whole plants depending on local customs, purpose or age of the plant. It is sometimes harvested earlier if needed for food. Storage roots become too woody if harvesting is delayed. Early maturing varieties are ready for harvesting at 7 months while late maturing varieties are ready 12 months after planting.

**Storage**   
Cassava does not store well when fresh and therefore has to be peeled, chopped and dried in the sun. It can then be stored in the form of chips or flour under dry conditions.

**Yields**

10-25 tonnes/ha in less fertile soils and 30-50kg tons/ha for best cultivars/variety

**Cassava Diseases**

1. **Cassava Mosaic**

Caused by a virus which is transmitted through infected planting materials and sometimes by white fly vectors (*Bemisia spp*)

The disease is mostly spread by use of infected planting materials.

**Symptoms**

-Mild twisting of leaves

-Severe stunting accompanied by

-distortion and yellow molting of the foliage and above ground parts

**Control**

* Use of mosaic disease free cuttings
* Use of resistant varieties
* Controlling the insect vectors
* Crop rotation
* Proper crop husbandry e.g. irrigation and fertilization to boost plant growth.

1. **Cassava Brown Streak**

Also a Viral disease particularly serious in coastal areas of Kenya, Zanzibar, Mozambique and Tanzania and lakeshore region of Malawi and in Uganda and is a threat to the whole of sub-Saharan Africa.   
The virus is vectored by whiteflies (*Bemisia spp*.) and also transmitted through infected cuttings.

**Symptoms**

-Brown streaks occur on green stems. The marks remaining and appearing as sunken areas on mature stems

-Brown horse shoe –shaped marks can be seen by cutting away the leaf scars and Black necrotic lesions are found on the roots. The leaves may appear healthy even when the roots have rotted away.

**Control;**

* Use diseased-free cuttings.
* Use tolerant/resistant varieties (e.g. 5543/156, TMS 30572)
* Remove diseased plants from the field.
* Controlling the insect vectors
* Crop rotation
* Proper crop husbandry e.g. irrigation and fertilization to boost plant growth.

**Utilization**

* Cooked as food
* Firewood
* Brewing
* Manufacture of starch
* Leaves used as vegetables which contain a high level of Vitamin A and up to 17 % protein,
* Animal feed

**END**

**SWEET POTATOES *(Ipomea batatus)***

Most important root crop in East Africa.

Used as food while the vines are used as animal feeds

**Plant characteristics**

* Is a perennial vine but often treated as an annual crop in Africa
* Each plant produces many trailing stems that seldom rise to more than 45cm above the ground
* When nodes touch the ground they produce tubers
* Leaf shape, tuber shape, tuber color and tuber/vine ratio differ widely depending on the variety.

I

**Ecology**

1. **Rainfall/water requirement**

They are drought resistant crops –the vines remain green and healthy during severe drought although tuber growth is negligible

They grow well in areas with annual rainfall of 750mm or more.

1. **Temperature /altitude**

Does well in warm and cool areas at an altitude of 2100m arid and semi-arid land and above

1. **Soils**

Grows in wide variety of soils

Responds well to farm yard manure and fertile soils

The soils should be well drained to avoid water logging and rotting of the tubers.

The soil PH should also be neutral

**Varieties**

White tubered

Red tubered

Useful varieties have been evaluated by Agric dept. include;

lagos white, SPK 013, mafuta, Exdiani, KSP20, Kemb20, large leaves, 0116

**Land preparation and planting**

Methods of land preparation differ widely in east Africa e.g. in UG they are grown in mounds which are 0.9m apart and 3-4 cutting are planted. In central province Kenya they grow on flat ground. However establishment on ridges is recommended for the following reasons

* Easy to harvest where they can uprooted by hand or simple tools
* Higher yields are realized since most/many buds are covered
* Less incidences of greening of the tubers since they are less exposed to the sun
* Less incidences of the tuber moth
* More water and soil conservation which is available for plant use
* Better root establishment, spread and expansion hence bigger tubers

Apical pieces of vines taken from mature points are used as cuttings and are planted at any angle with ½-3/4 of their length buried. The cuttings vary from 23-90cm in length. Ridges are 0.9-1.5m apart with vines 0.3-0.6m apart. When pieces are short in supply maybe taken from middle or a basal part wilted for a few days to initiate rooting

**Fertilizer and manure application**

Farm yard manure is the only manure found to give a good response

**Weeding**

Not a great problem because sweet potatoes are hardy. Hand weeding can be done during the first two months

**Harvesting**

The 1st tuber can be harvested 4-5 months after planting and is done piecemeal (progressive) harvesting because of storage problems. Can be sliced and dried so that it can be stored for a considerable period. Sharpened sticks are always used

Yields vary from 2.5t/ha to 50 t/ha with average 35t/ha

**Pests**

1. **Sweet potatoes weevils (*Cylas spp*)**

Larvae tunnels vines and tubers causing bitterness and discoloration in tubers dwarfing and yellowing of vines

**Control**

* Crop rotation
* Chemical control

1. **Sweet potatoes virus B**

It is the stunting disease transmitted by whiteflies. It causes stunting, excessive branching and yellowing of the vines and cork symptoms may develop in the tubers

**Control**

* Use of resistant varieties

**END**

**IRISH POTATOES (*Solanum tuberosum*)**

It belongs to the **solanaceae family** and Originated from highlands of South America (Peru) and was introduced by British farmers in 1950s.

It is important root crop in Kenya and grown at high potential areas, also it is world largest food crop after maize, rice, wheat and more suitable substance crop than maize because it takes less than a year to mature. It acts as a staple food crop as well as cash crop for many rural and semi urban dwellers playing an important role in improving national food security and income generation for those involved in its value chain development.

**Plant characteristics**

A potato tuber is a swollen underground stem.

On its surface are a number of eyes of which is a bud axil of a scale leaf. After undergoing a period of dormancy for 3-4 months some of these buds sprouts and produces stems.

One eye can produce more than one stem owing to branching at the base of the original stem. The nodes of the stem produce roots and later shoot stolons whose ends well into tubers. It produces flowers whose petals are white, pink, blue or purple according to variety; as a general rule coloured flowers give rise to coloured tubers while White flowered ones give white skinned tubers.

**Ecology**

* **Rainfall and water requirements**

Crop requires 500 -100mm well distributed rainfall/year. Steady rainfall of about 25cm a week is needed to maintain optimum growth**.** The rains should continue for three and half months for good yields.

* **Altitude and temperature**

Does well in cooler conditions above 1800m .The optimum day temperature of 20- 25oC are ideal. At this altitude potatoes grow faster than maize and produce more energy and protein per ha per day. Such areas include those surrounding Mt. Kenya namely; Meru, Embu and Kirinyanga; parts of Laikipia and both sides of the Aberdare range which include parts of Nyeri, Muranga, Kiambaa and Nyandarua Districts. Other areas include Mau Narok, Molo, Tinderet, Nandi Escarpment and Cherangani hills. Kericho, Kisii and around Taita hills have also been reported to grow potatoes too but in small acreages.

* **Soil requirement**

Soils must be well drained and fertile with high organic matter content**.** Heavy soil restricts tuber expansion and makes harvesting difficult. Soil PH of between 4.8 and 6 are ideal, higher soil PH causes incidence and severity of potato scab diseases.

**Varieties**

Duta Robijri- Ngorobu

Rosin Eburu

Kerr pink

Kenya akiba

Tigoni

At samba

**Field operations**

**Planting/Propagation**

Small tubers (seed/setts) are used for propagation. Before planting, they should be pre-sprouted/chitted.this involves spreading them in a thin layer not more than 2-3 tubers deep in presence of diffuse light and very well ventilated environment. Complete darkness should be avoided as it causes development of long, white, thin sprouts that are etiolated and easily broken during planting.

Reasons for chitting include;

* Encourages the development of short, green, strong and healthy seedlings
* Stem growth starts immediately the seed is planted making use of the available rainfall
* Causes even and rapid emergence covering the soil and conserving moisture
* Gives rise to multi sprouts, hence many stems. This translates to higher yields.
* Pre sprouted tubers can be stored for 2-3 months before planting

The tubers are planted in ridges 0.75m apart and 10cm deep and 23- 30cm apart in rows

Planting should be done at the beginning of the rains.

Botanical seed can also be used but takes longer to develop than tuber seeds.in addition, there is a lot of segregation due to crossing hence the resulting potatoes are not uniform and true to type and are therefore not desirable for commercial purposes.

Tissue culture technique achieves rapid multiplication of planting materials that are disease free.

**Fertilizer and manure application**

Nitrogenous and phosphatic fertilizers increases yields 22-45 kg/ha of P2O5

FYM gives good respond

**Weeding**

Done within the first six weeks afterwards, it is not necessarily if there is a good stand and ground cover.

Ridging done soon after emergency because it prevents;

-Spores of late blight from reaching the tubers

-Control weeds

- Prevents greening of developing tubers

**Harvesting**

Done by hand and should be protected from direct light to avoid greening

The tops are cut or pulled off two weeks before harvesting to harden the skin of the tubers thus less bruises during transport potatoes cannot be stored for long periods in East Africa because of high temperature which encourages sprouting

They can be stored in soil conveniently in the dry season although there is a risk of nematode damage. They can be also left for more than 4-6 weeks or under specialized care in cold warehouse

Yields vary from 5.0-7.5t/ha to as much as 40t/ha in commercial farms

**Pests**

**Potato aphid**

***Aulacorthum solani*** transmit virus disease

**Diseases**

**Late Blight**

Late blight is caused by fungus ***Phytophthora infestans***. Severe in east Africa and most important factor limiting yields because;

1. There is absence of prolonged dry periods to check the disease growth or winters
2. Same climatic requirements for the fungus and the crop i.e favored by cool cloudy, wet conditions

**Predisposing factors/environmental conditions influencing manifestation of potato late blight.**

i) Moisture

Moisture on the surface of the leaves creates an environment suitable for spore germination. Well watered plants especially using sprinkler irrigation are vulnerable to the fungus.

ii) Temperature

A low temperature favours *Phytopthora infestans* growth. Low temperatures also weaken the resistance of the potato plant.

iii) Relative humidity

The fungus requires a high relative humidity for spore germination and penetration of the germ tube.

**Symptoms**

There areirregular brown necrotic patches on the leaves. These spreads rapidly if weather is wet and humid and finally all vegetative part are destroyed spread by infected seeds infected debris in the soils spores

**Control**

* Plant resistant varieties e.g. Kenya Akiba
* Use of fungicides
* Crop rotation

**Bacterial wilt**

Bacterial wilt is destructive at lower altitudes. Once the soil is contaminated it remains so indefinitely and is caused by bacteria ***Pseudomonas/Rastonia solanacearum.***

**Symptoms**

Characterized by rapid wilting of vegetative parts and death without yellowing and spoiling of leaves.

A white bacterial mass oozes from the vascular tissue when the base of the stem or a tuber is cut. It is spread by seed tubers and furrow water

**Control**

* Use of clean certified seeds
* Soil fumigation-
* remove wilted plant to reduce spread of diseases
* Crop rotation
* Resistant varieties

**Utilization**

Boiling

Frying

Roasting

**Constrains facing potato industry**

* Production is bi-modal, that is, it is only produced twice a year following the rainfall pattern of Kenya. Around July to August period, potatoes are usually in high volumes and fetch low prices while in December, April and May they are usually in low supply fetching higher prices for farmers involved.
* Due to continuous production of potatoes in the same piece of land, soil degradation has been inevitable.
* Fertilizer application has been done below the recommended rates with the most common one being Di-Ammonium Phosphate. It should be noted that fertilizer leads to increased soil acidity.
* Poor use of certified seeds. About 1% of the planted area only has recorded use of certified seeds. The other plantations are done using seeds raised locally through retention from previous harvest which farmers obtain from their stores or buy from local markets, friends and relatives. Yield reduces with each successive generation.
* Diseases such as brown rot and late blight,
* Lack of crop rotation where farmers cultivate potatoes in the same piece of land over and over again,
* Poor storage facilities and
* Lack of enough capital for capital intensive production which can see their overall production increase as result of employing motorized machinery.

**END**

**LEGUMES (PULSES)**

**Economic importance of legume crops**

* Source of proteins to animals and human-Beans are referred to “poor man’s meat”
* Help fix Nitrogen into the soil e. g beans hence less need to apply inorganic fertilizers
* Acts as a cover crop to prevent soil erosion
* Suppress weeds by providing ground cover-Most of them are broad leaved and low growing
* Leguminous trees produces wood fuel
* Provision of organic matter to the soil which helps improve soil structure.
* Crop labour requirements are low, therefore lower production cost
* Fast maturing, require less water and frees land for establishing other crops
* Not seriously affected by many pests and diseases hence less frequency of spraying.

**1. BEANS (*Phaseolus vulgaris*)**

**Introduction:**

Beans are the most important legume in Kenya except the coast. Commonly referred to as ‘’poor man’s meat’’ since they are inexpensive sources of proteins compared to meat, milk, eggs and fish.

Beans are usually intersown with maize.

Are sold in Kenya for canning or exported to Europe. When cooked in tomato sauce, they are known as baked beans. It’s difficult to establish acreage since they are mostly intercropped

**Plant characteristics**

* Annual crop
* Nodules form and fix N
* Most EA varieties are determinate with bush type growth habits but also indeterminate and climbing types exist.
* Flowers vary in colour depending on variety but white, pink, yellow, red and purple colours occur.
* Seeds are borne in a pod and vary in size, shape and colour
* Mostly 100% self-pollination
* Broad leaved and well developed feeder roots

**Ecology**

Requires moist soil throughout the growing period. Rainfall towards end of the growing period is undesirable as it causes high incidence of pests and diseases and also can dis colour seeds making such seeds of low market value.

Altitude and temperature

Beans do not do well at high temperature and low altitudes because it causes poor pollination hence poor fruit set. They are best suited to medium altitude areas between 900-2100m ASL.

Soils

Requires well drained fertile soils

**Varieties**

1. Pure line varieties include Canadian wonder (GLP- 24)

2. Mixed varieties e.g. Rose coco (GLP-2)

3. GLP-1004 (mwezi mmoja)

4. GLP-585 (Red haricot/wairimu)

5. GLP-92 (Pinto bean/mwitemania)

**Field operations**

Beans do not need fine seedbed because the large seed sizes hence a medium tilth seedbed is suitable. Beans are mostly intersown with other crops especially maize. Planting method is by dibbling (random planting), however row planting is recommended. Spacing in semi-arid areas is 45x10cm when grown as a mono crop or 40x20cm. 2 seeds are planted per hill. In high potential areas, a closer spacing of 30cmx10 or 30cmx15cm is recommended.

Seed inoculation with the right strain of rhizobium before sowing is recommended to improve the nitrogen fixation.

**Fertilizer application**

Nodules are sometimes small or absent. Therefore the amount of N fixed by BNF is insignificant. Beans show response to N and P and therefore 46KgP2O5/Ha and 18KgN/Ha are recommended. If the beans are grown as pure stand, 150-200kg DAP should be applied. Organic manure should also be applied to improve the physical conditions of the soil.

**Weed control**

Small scale farmers use hand weeding. Chemical control is discouraged as beans are susceptible to most herbicides.

**Harvesting**

Small holder farmers uproot whole plants. They are then taken to homesteads and dried on bare earth or mats. Drying time depends on weather and extends of drying before harvesting. The recommended safe moisture content for safe storage is 14%. Once dried, they are beaten with sticks to separate the seeds from the pods. Cleaning is done by winnowing to separate the seeds from chaff.

**Pests**

**Bean flies (*Melanogromyza spp*)**

This is the most important damaging pest of beans causing a yield loss of 60%.The adult flylays eggs on the bean leaves or hypocotyl and after hatching the larvae (maggots) starts feeding on the cotyledons for 10days and bores downwards and pupates in the stems at the ground level. The bases of the attacked plants become swollen and crack. Such plants are ineffective in absorption of water and nutrients and most die. Survivors become stunted and yellowish with poor yields.

Control

* Seed dressing with insecticides such as aldrin, dieldrin, endosulphan
* Furrow application with carbofuran during planting
* Early planting allows disease escape
* Use more tolerant varieties e.g. mwezi mmoja. They tend to produce adventitious roots.
* Removal of volunteers and crop residues in the field
* Hilling/Mounding-This encourages formation of adventitious roots
* Avoid overwatering during irrigation
* Mulch the plants.

**African boll worm (*Heliothis armigera*)**

Young larvae make circular holes in the sides of the pods and eat the contents.

**Bean aphids (*Aphis fabae*)**

These are black, sap sucking insects occurring in clusters around growing points, stems, leaves and flowers. If present in large numbers, they can prevent normal growth. Yellowing and distortion of leaves is common symptom of attack. Spraying with endosulphan is recommended.

**Bean bruchids (*Anthoscelides obtectus*)**

This is the main storage pest of beans and also attacks most of other pulses. Adult beetles lay their eggs in the field on the developing pods. The larvae bore through the pod walls and into the seeds. They are so small that their entry holes are almost invisible. As the seed grows, the damage holes disappear. The larvae feeds inside the seeds and each makes a tunnel almost to the surface in which case only the seed coat is left intact, forming a window at the end of the tunnel. After pupation, the adult beetle emerges by pushing out the flap of the seed coat, leaving a circular hole. Although some eggs are laid in the field, most are lid by adults emerging in the stores loosely among the beans and can cause rapid increase in the number of infested seeds.

Control

Mixing seed with gamma-BHC dust or grain storage dust as actellic super.

**Diseases**

**Bean rust (Cause: *Uromyces phaseoli*)**

Many small red pustules grow on the underside of the leaves. A characteristic dark green spot surrounded by a small yellow circle appears on the upper side of the leaf above each pustule. Severely infected beans become deformed and fall early.

**Bean anthracnose (Cause: *Colletotrichum lindemuthianum*)**

Causes brown or black lesions on the underside of leaves, stems, petioles and pods. Stem and petiole lesions are sunken and longitudinal. Pod lesions are sunken and circular. Each has a well-defined black mark on the underside of the veins.

**Halo blight (Cause: *Pseudomonas phaseolicola*)**

It’s a Cool and wet disease characterised by irregular dark spots on the leaves or pods. Each dark spot is usually surrounded by a yellow halo. Well-developed lesions have a water soaked appearance and their centres fall off.

**Angular leaf spot (*Phaeoisariopsis griseola*)**

Causes brown spots on the upper surface of the leaf. Lesions are irregular in shape as they are bounded by veins. The underside of each lesion is black and hairy.

**General control of bean diseases**

* Use of fungicide sprays e.g. Dithiocarbamates
* Certified/disease free planting materials
* Use of Disease resistant varieties
* Field hygiene and sanitation
* Crop rotation
* Control of insect vectors in case of viral diseases.

**END**

**PIGEON PEAS (*Cajanus cajan*)**

**Introduction**

Most important pulse crops in lower altitude areas of E.A particularly lower parts of East and Central provinces. Origin: Africa or India.

**Plant characteristics**

* Pigeon peas are short lived perennials legumes.
* Have deep woody tap roots
* Stems grow up to 3.5m
* Leaves are trifoliate with narrow leaflets
* Usually yellow flowers but also red and orange flowers occur in some varieties.
* Pods have 4-6 seeds but up to 8. Marked depressions on pods between each seed.
* Mostly Self-pollinated but up to 40% cross pollination occurs
* First pods are ready for harvesting 5months after sowing in case of local varieties.
* Life of crop is 2-3 years but in Kenya its only 1 year due to soil borne diseases e.g. Fusarium wilt

Varieties

* Flavus-short, early maturing and three seeded
* Bicolor-late maturing, bushy and 4-5 seeded
* Munaa and kioko-improved varieties, taking 6-7 months to mature
* NPP 670-Take 4.5-5 months to mature

**Ecology**

Altitude 1500-2000m ASL

Crop is Deep rooted and drought resistant. Can do well below 600m a.s.l in machakos, kitui and makueni where the crop is grown as a biennial crop.

The crop Does well in fertile, deep and well-drained soil.

Field operations

In Kenya, the crop is intercropped with beans and maize at the start of the long rains. They later remain as pure stands after the other crops have been harvested.

Spacing is 1.5mx1.2m

Ratoon crops are common and sometimes yield better than main crop.however, suitable ratooning method is being researched on whether to pick pods alone or pick pods and cut back. Yields are low 470-670kg/Ha but with good management yields of 1100kg/Ha are achievable.

**Pests**

Common pests include root mealy bugs, African bollworm and pod fly.

**Diseases**

Fusarium wilt caused by the soil borne fungus *Fusarium udum*

This is a major disease of pigeon peas in Kenya.

Disease symptoms include blackening of the stem and the internal tissues of the roots. Individual plants show wilting in the field even in present of moisture.

**Utilization of the crop**

-Source of food; mainly boiled with maize

-Potential canning market

-Grown as a boundary/border plant, hedges and as windbreakers

-Source of wood fuel

-Livestock feeding

-Improvement of soil fertility by biological nitrogen fixation.

**GROUNDNUTS (*Arachis hypogea*) - Farming in Kenya**

** **

**Why venture into groundnuts farming?**

This is an annual oil crop. The seeds are rich in oil 38-50%, protein 25%, calcium, magnesium, phosphorus, potassium and vitamins.

They are reported to have medicinal value particularly in the treatment of diarrhoea and haemophilia.

* Groundnuts are processed into oil used for cooking.
* Groundnuts boost fertility
* Help fight depression
* Boost the human memory power
* Important in blood sugar control
* Cancer prevention
* Prevents gallstones
* Very low in cholesterol
* Lowers heart problems
* The cake that comes out of oil press is ground into flour and used in many human foods as its rich in protein.
* Reduces the risk of weight gain

**Introduction**

The scientific name for groundnuts plant is Arachis hypogaea while the local name is njugu Karanga. Groundnuts originated in South America. They are now grown from seed in most tropical, Subtropical and temperate countries between 40 N and 40 S latitudes, particularly in Africa, North America, South America and Asia. The seeds are rich in oil 38-50%, protein 25%, calcium, magnesium, phosphorus, potassium and vitamins. They are reported to have medicinal value particularly in the treatment of diarrhoea and haemophilia. Most of the world groundnuts are processed into oil used for cooking. The cake that comes out of oil press is ground into flour and used in many human foods as its rich in protein. The seeds are eaten raw, as roasted snack, used in confectionary, used in soups and made into sauces to accompany meat and starchy dishes. In Africa the plant is grown by small scale farmers both for cash and subsistence.

In Kenya the crop is mainly grown on Western, Nyanza and Homa-bay.

**Plant characteristics**

* Is a low growing annual legume
* Roots are well nodulated
* Varieties have alternate branching with upright main stem and 5-6 branches at acute angles to it
* Have an erect bunch growth habit
* More spreading types known as runner types and less spreading are bunch types
* Leaves are pinnate
* Each inflorescence bears many yellow flowers between 1-2 months after sowing
* Pollination occurs before flower opening, therefore cross pollination is rare
* After pollination, yellow flowers are shed; the meristem at the base of the ovary becomes active and grows to form a peg. The peg grows downwards bearing the ovary at the tip. The tip of the peg is lignified to protect the ovary when it penetrates the soil. The growth of the peg makes the ovary horizontal just a few inches below the soil surface.
* The fruit is an elongated pod containing1-6 seeds covered by a thick fibrous shell.
* The seeds have a testa which is paper like when dry and may have white, red, pink purple or brown.
* Time of maturity is 90-130 days depending on variety and altitude

**Climate water and soil requirements**

* The crop grows well in warm tropics and subtropics below 1500 M above sea level.
* Optimum daily growing temperatures requirements are 30º C and growth stops at 15º C.
* The plant does not tolerate frost and cooler temperatures delay flowering and seed formation.
* Water requirements are 500 to 600 mm well distributed throughout the growing season for good growth. Good rainfall distribution is required as drought causes poor vegetative growth, poor peg penetration if the soil is hard and also development of small shrivelled nuts.
* The crop is drought resistant and can survive severe lack of water but yields are reduced.  
  Pods grow underground crumbly free draining soils are required. But the plants also grow well in heavier clay soils.
* Harvesting in wet condition should be avoided, to prevent development of aflatoxin, a severe poison produced by Aspergillus spp of fungus, which releases chemicals dangerous to human health. The fungus causes both seeds and seedlings to rot. The infected seedlings are covered with black fungal spores. PH requirements range from 5.5 to 6.5.
* The soils should be loose, well drained, fertile and light because heavy soils make it difficult to remove nuts from the ground as pieces of sol adhere to the pods.

**Crop propagation and varieties**

**Seed dressing:** To control seedling blights caused by soil bacteria and fungi, and also other fungal diseases, a fungicide treatment is recommended. Thiram gives good protection and can be applied as a dust at 120 g of thiram/100 kg of seed. The dust must be uniformly mixed with the seed.

**The planting date** is difficult to standardize. However, farmers should plant as soon as there is adequate moisture in the ground to ensure good germination. In general, groundnuts are planted between February and April during the first season and in early August for the second season. Planting in the first two weeks after the onset of rains is considered suitable. Planting early in the season helps to improve yields and seed quality, and reduce the incidence of rosette disease. Long duration varieties should only be planted with the first rains in the first season. Short duration varieties can be planted in either season.

Planting date is linked to rainfall distribution in the area and length of the crop season. Soil moisture must be sufficient to guarantee good germination. Seeds must not be sown immediately after heavy rains since they imbibe too much water, which causes rotting. This also results in excessive soil compaction, which may hinder germination.

In general early sowing improves yields (significant delay in sowing can reduce yield by 50%) and seed quality  
Seeds should be sown at a depth of 5–8 cm. To ensure uniform sowing depth, germination and crop stand, it is suggested that a groove 5–8 cm in depth is made along the rows for planting and, once the seed has been planted at the right depth and spacing, the soil is pressed down to ensure good contact with the seeds, enabling them to extract moisture more effectively. It is important to sow groundnut seed in rows and at the right spacing as this helps to reduce the incidence of rosette disease, ensures a more uniform pod maturity, better quality seed and maximizes yield. Planting groundnut plants closer together results in individual plants setting fewer pods, but over a short period of time. Overall, this will ensure that the pods will be of a similar age and stage of development and, therefore, make it easier to decide when to harvest. Wider spacing will produce fewer yields per hectare.

**Spacing** depends on the growth habit and the variety. Small seeded Spanish types (bunch) are spaced at 30-45 cm between rows and 7.5-10 cm between plants. This gives an optimum plant population of 167,000 per hectare. The large-seeded Virginia types (runner) are spaced at 60 cm between rows and 10-15 cm between stations, giving an optimum plant population of 89,000 per hectare. Under irrigation, plant population can be as high as 250,000 plants/ha. This depends on variety characteristics, seed quality and planting density. With manual sowing, individual seeds are sown 3-5 cm deep.

Plough the land and harrow to a good tilth. Prepare ridges which are 80cm apart with flattish tops. Seeds for sowing should be stored in their pods to be shelled a few days before planting. The seeds are planted in two rows on top of the ridge. Select clean well filled seeds for planting. Sowing seeds to a depth of 5-8 cm at a seed rate of 40-50 kg per ha is recommended depending on the seed size.

Groundnuts have two main types namely:-

1. Bunch type e.g. Red Valencia maturing within 90 – 100 days
2. Runner type e.g. Homa Bay maturing in 120-150days

|  |  |
| --- | --- |
| **Variety** | **Mean  Kernel yield**  **Kg/ha** |
| Red Valencia | 1500 |
| manipinta | 2450 |
| Makulu Red | 2750 |
| Bukene | 1530 |
| Asyria Mwitunde | 1300 |
| Texas peanut | 1360 |
| Severe 116 ( white) | 1250 |
| Atika | 900 |
| Homa Bay | 770 |

**Field operations**

**Weeding**: Groundnuts compete poorly with weeds particularly during the early stages of growth. Earthing up should be done at the time of weeding to encourage pegging which refers the penetration of young nuts into the soil. Careful Hand weeding is recommended after initiation of pegging to prevent disturbance to the growing nuts or damaging the flowers. Clean weeding should take place up to 6 weeks after which only hand weeding should be done. Groundnut cannot compete effectively with weeds, particularly 3–6 weeks after sowing; therefore, early removal of weeds is important. Generally, 2 weedings are recommended, the first before flowering and at least another during pegging. If early weeding is done well, and crop spacing recommendations followed, then the weeds that come up later are smothered with the vigorous growth of the crop.

When weeding, it is very important to avoid covering the developed plant with earth (including earthing up) as this can increase diseases (e.g. white mould), reduce flowering and pod development and, therefore, reduce pod yield. Once flowering and pegging begins it is advisable to weed by hand pulling, rather than by using a hoe, as this is less likely to disturb any developing pods.

**Fertilizer application:** A reasonable level of organic matter must be maintained in the light, weakly structured, tropical soils where groundnuts are grown. Groundnut requires adequate levels of phosphorus, potassium, magnesium and particularly calcium, which are required for maximizing yield and good quality seed. For farmers who can afford artificial fertilizers, application of Single Super Phosphate (SSP) at the rate of 100–125 kg/ha or Triple Super Phosphate (TSP) at 80–90 kg/ha will boost yield. SSP or TSP should be worked into the soil before planting. In areas where there is a high incidence of empty pods (‘pops’), there could well be a shortage of calcium in the soil. To rectify this, depending on the soil type and seed variety a treatment of Gypsum at the rate of 200–400 kg/ha (up to 500–1000 kg/ha if the soil is particularly poor) at early flowering will reduce the incidence of empty pods. This requires soil analysis.

Calcium is critically required during the pod formation stage and lack of it results in empty pods. Generally nitrogen fertilizers are not required as the plant is leguminous and fixes Nitrogen. In acidic soils lime can be applied to raise the PH and supply calcium. Moisture stress at flowering or pod formation stages reduces yields and therefore supplementary irrigation may be required for increased production and high quality seed.

**Pest and diseases**

The major pests and disease challenging groundnut growing are shown below:-

|  |  |  |  |
| --- | --- | --- | --- |
| **Pest or disease** | **Stage attacked** | **Type of damage** | **Control measures** |
| White grubs | All stages | Roots, pods, young nuts | Well decomposed manure |
| Termites | All stages | Roots, stem base, pods | Early planting, field hygiene, timely harvesting. |
| millipedes | seedling & plant | Pods, flowers | Cover exposed pods, close soil cracks |
| Aphids | Early growing stages | Vector of rosette virus | Early planting, conserve natural enemies e.g. ladybirds. |
| Damping off disease |  | Rotting of stems Seedling, petioles | Certified seed, crop rotation |
| Leaf spot | leaves | Brown ring spots Shedding leaves | Crop rotation, field hygiene |
| Rust | All aerial parts except flowers | Leaves, stems | Remove volunteer groundnut plants, crop rotation |
| Aspergillus crown rot | All growth stages | Wilting  of the plant | Rapid drying of nuts to 10% M.C |
| Bacterial wilt | All stages | Plant wilting | Rotation with cereals |
| Groundnut rosette Virus | All growth stages | Yellowing, mottling, stunting | Early planting, control of vector-Aphids |

**Groundnut Diseases and their Control**

Groundnut production is adversely affected by a large number of fungal, viral and bacterial diseases. Most of these are widespread, but only a few of them are economically significant. The major diseases include groundnut rosette, ELS, LLS, rust and aflatoxin contamination.

**1.** **Groundnut rosette disease,** a viral disease transmitted by aphids, is the most common and most significant disease of groundnut in all regions where this crop is grown. It has been a major factor in the decline of the groundnut yields.

Symptoms

The disease can manifest two types of symptom: green or yellow (chlorotic). The affected plants are stunted and present a bushy appearance with a marked reduction in leaflet size with visible mottling.

• Yellow (chlorotic) rosette causes plants to initially develop a faint mottling on young leaves.

Subsequently, leaflets are yellow with green veins. Plants infected when young produce progressively smaller, distorted, curled and yellow leaflets, while the symptoms in older plants are generally restricted to a few branches or the apical portion of the plant.

• Green rosette disease shows middle mottling on young leaflets with some leaf curling, but leaves are not distorted. Plants infected when young are severely stunted and dark green in colour. Total yield losses have been reported in susceptible varieties. Early infected plants produce no yield and there is no control once a plant is infected.

A 100% loss in pod yield due to either chlorotic or green rosette disease may result if infection occurs before flowering. Control of aphids will prevent further spread of the disease.

Management 1. Chemical control

• Spray the entire plant with insecticides, 14 days after emergence (usually 5 ml per 2 l of water, but check the label for instructions) and then at 14-day intervals with a total of three sprayings.

Management 2. Cropping practices

• Planting should be done as soon as there is enough moisture in the soil

• Close planting should be adopted

Closely planted groundnuts providing a good covering of the soil against water loss

• Intercropping with cereals (maize, millet or sorghum) has been found to be effective in reducing the disease incidence

Groundnuts inter-cropped with sugarcane

Note: Early sowing and close spacing of rows reduce disease incidence

Management 3. Host plant resistance

• Rosette-resistant varieties should be used for planting.

Management 4. Cultural control

• Crop rotation with crops like maize has been shown to provide partial management of leaf spots

• Early sowing has been shown to reduce the severity of leaf spot diseases. The date of sowing should be adjusted to avoid conditions favourable for rapid disease development.

• Burying all groundnut crop residues by deep ploughing will reduce initial inoculum. Chemical control

• Multiple applications of a fungicide such as Benomyl, captafol, chlorothalonil, copper hydroxide, mancozeb or sulfur fungicides may control ELS and LLS. However, carbendazim (0.05%) has been found to control both leaf spots very effectively.

• Three sprayings of 0.2% Chlorothalonil at intervals of 10-15 days starting at 40 days after germination up to 90 days provides effective control to ELS and LLSs. Use of resistant lines • Grow cultivars tolerant to LLS: Sources of resistance to both ELS and LLSs have been identified in groundnut and used to develop varieties with resistance. Recently released groundnut varieties in Nigeria are tolerant to foliar diseases.

**2. Bacterial Leaf spot**

There are two main forms of the leaf spot fungal disease – early and late. Early leaf spot may occur as early as 2 weeks after crop emergence. Lesions produced by this fungus are roughly circular, dark brown on the upper surface with chlorotic (yellow) halos surrounding the darker lesions and a lighter shade of brown on the lower surface of the leaflets. Severe attacks can cause heavy defoliation and result in a large yield loss.

Late leaf spot occurs later in the season and has nearly circular lesions which are darker than those of early leaf spot. Late leaf spot does not normally affect yield reduction as severely as early leaf spot. On the lower leaf surface where most of the sporulation occurs, the lesions are black.

Since the leaf spot pathogens survive mainly in crop debris, cultural practices such as crop rotation, burying crop debris during land preparation and early sowing can significantly reduce the incidence of the diseases.

Chemical control may not be economical for rain-fed crops but the fungicides ridomil, milraz or mancozeb (Dithane M-45®) can be used at the rate of 50 g of the chemical with 20 L water. Apply when lesions are first seen and then at 14- day intervals for 3–4 sprays.

**3. Groundnut Rusts (*Puccinia arachidis*)**

This is one of the important foliar diseases that reduces seed quality and causes substantial losses to groundnut production worldwide.

Rust occurrence is generally sporadic but sometimes there are severe outbreaks. It can survive in volunteer plants and spores can disperse over long distances to infect other areas. Rust is characterized by orange-red pustules on the leaves which later turn dark brown and cause curling of leaflets and defoliation.

Cultural Control

• Crop rotation and field sanitation. This helps to reduce the initial inoculum in the soil

• Strict plant quarantine regulations should be enforced to avoid the spread of rust on pods or seeds to disease-free areas

• Early sowing minimizes incidence of the disease

• Intercropping cereal (maize, pearl millet or sorghum) with groundnut has been found useful in reducing the intensity of rust.

Mechanical Control

Destroy volunteer (self-sown) groundnut plants and crop debris to reduce/ limit primary source of inoculum.

Chemical Control

There are some chemicals effective for the control of rust disease, and these should be applied as soon as the symptoms are noticed. Some of the chemicals used are Chlorothalonil 0.2%, Mancozeb 0.25% and Hexaconazole/ propaconazole. Use of resistant varieties. In places where rust disease is endemic (common), the use of resistant/ tolerant varieties in combination with a little chemical control provides the best results.

**4. Aflatoxins**

Aflatoxins are a group of toxic metabolites produced by the fungi *Aspergillus flavus* and *Aspergillus parasiticus.* Aflatoxins are some of the most potent toxic substances found in foods and feeds.

Scientific research shows that aflatoxin can cause various types of cancer in both animal species and humans. It has been reported to cause severe illness and death in many parts of the world.

Chronic intake of aflatoxin in animals can lead to poor food intake and weight loss. Aflatoxin contamination can occur in the field, during postharvest drying and storage, and even during transportation. Crop husbandry practices, mechanical damage, insect and bird damage, climatic conditions (drought, stress or excessive rainfall), and soil factors, in addition to host-plant susceptibility, significantly influence aflatoxin contamination.

**Recommended postharvest practices to manage aflatoxin infection:**

• Do not delay harvest when groundnuts have reached maturity

• Immediately after harvesting, pluck the pods off the haulms and place to dry as soon as possible

• Harvest carefully to avoid mechanical damage. This is particularly important if hand hoes are used to harvest the pods.

• Avoid field drying of groundnuts when attached to haulms as aflatoxins increase with delays of produce in the field.

• Do not dry produce in contact with soil. Use clean sheets, for example polythene sheets or tarpaulin or mats made of papyrus, cemented grounds or raised structures

• Dry harvested pods to moisture content level below 13%

• Avoid mixing diseased or infected pods with healthy ones.

• Separate out immature pods as well as those infested with pests and diseases during shelling

• Do not shell by beating or trampling on groundnut in shells. Manual or motorized shelling is recommended but care should be taken that the shellers do not damage the pods. Use hand or motorized shellers specifically designed for groundnuts

• Do not sprinkle water on dry pods while using mechanical shellers. Instead, adjust (where possible) the space between blades and the sieve according to pod size to reduce breakage

• Remove shrivelled, discoloured, mouldy and damaged grains from the lot including groundnuts with damaged testa and dispose them.

• Remove dust and foreign material which can be a source of contamination.

• Properly dry groundnuts for safe storage to moisture content to less than 10%

• Place them in packages that will maintain suitable environment and prevent or restrict moisture pick-up and insect/rodent infestation

• Use new/clean gunny or polybags to store the groundnuts

• Do not place bags directly on floor

• Do not heap groundnuts in shells/pods on the floor/ground inside storage structure

• Maintain proper storage facilities (well-ventilated, dry and with low relative humidity) and take care not to expose produce to moisture during transport and marketing

• Control insects and rodents during storage

• Do not mix new produce with old stock.

**HARVESTING GROUNDNUTS**

**Timing**

It is very important to harvest groundnuts at the correct time. Flowering is indeterminate in the groundnut; therefore there are a variable proportion of mature and immature pods at the end of the crop cycle. Groundnuts are mature when 70-80% of the inside of the pods shells have dark markings and the kernels are plump, with colour characteristic of that variety. If harvested too early, the seeds will shrink when drying which lowers the yield, oil content and quality of the seed. Delays in harvesting will result in poor quality seed due to mould infections and subsequent aflatoxin contamination of the seeds/pods. Late harvesting also reduces yield because higher proportions of pods are left in the ground due to the pegs being weak and the pods breaking off. If harvested late, some non-dormant varieties will begin to sprout in the field resulting in yield losses.

**Indicators for harvesting time**

Leaf fall is not a good indicator of when to harvest. It is recommended that a few plants (3–5) should be pulled up randomly and the pods removed and shelled. The insides of the shells should be examined. If the majority of pods (70% upwards) have dark markings inside the shell and the seeds are plump and the correct colour for that variety, then the groundnuts are mature and ready for harvest. If the crop is severely defoliated as a result of disease (only one or two leaves per branch) or if sprouting has begun, the crop should be harvested regardless of maturity. The estimated period of maturity for each variety can be used as a rough guide.

**HARVESTING METHODS**

Handlifting   
Harvesting by hand only is more suitable for the bunch/erect groundnut varieties in sandy, loam soils which are well drained. When the soil is wet and heavy or very dry, it is much more difficult to pull up the whole plant without losing pods.

Hand lifting with a hoe

By using a hoe during harvesting it is possible to lift plants out of heavy or dry soil with a reduced pod loss. Spreading/runners varieties can also be more easily lifted. Care should be taken not to damage the pods with the hoe as damage makes the pods susceptible to fungal attack. A hoe fork lessens the likelihood of such damage.

**Cleaning**

It is important to shake the plant after lifting to remove excess soil from the pods, particularly when the soil is wet or heavy. Soil stuck to the pods will lengthen drying times and produce better conditions for the development of unwanted fungal growth.

**Drying**



The primary objective of curing or drying is to achieve a rapid but steady drying of pods in order to avoid aflatoxincontamination. Harvested plants should be staked in the field and left there for a few days to allow them to dry in the sun and air, before stripping the pods. The correct drying or curing of the harvested groundnuts is very important as poor curing can help induce fungal growth (producing aflatoxin contamination) and reduce seed quality for consumption, marketing and germination for the following season’s planting.

The moisture content of the pods should be reduced to 6–8%. This can normally be achieved by drying the pods in the sun for 6-7 days, taking care to cover them if it rains.

There are different ways of drying the pods, some of which are better than others. It is particularly important to note that if the pods are exposed to the sun for too long the seed quality can deteriorate considerably and germination can be affected. The different methods of drying are explained below.

* Drying in windrows
* Drying on mats
* Decortication or Shelling

Shelling is usually done by hands. However, hand-operated machines are currently available. Care should be taken to prevent cracking of the kernels. The following steps are important for maximum benefit in groundnut decortication:

• Separate immature pods as well as those infested with pests and diseases

• Do not shell by beating or trampling

• Either manual or motorized shelling can be used, but only if the shellers do not damage the pods

• Remove shrivelled, discoloured, mouldy and damaged grains from the lot including groundnuts with damaged testa and dispose them

• Remove dust, and foreign material which can provide a source of contamination.

**Stripping–winnowing**

This operation consists of separating the pods from the vegetative parts of the plants (vines). In traditional farming systems, manual stripping is the rule. Pods are individually detached from the vines and therefore dry very quickly stabilizing at 6-8% moisture content. The process results in a perfect quality product. This technique is used for the production of edible or confectionery groundnuts in order to minimize pod damage and contamination by Aspergillus flavus. However, stripping is most often done using sticks. These reduce the heap of groundnut plants into a mixture of chopped vines and partially broken pods that are then separated by winnowing.

**Storage Requirements**

Groundnuts should be stored under the following conditions:

Collect quality raw material (well filled mature pods), clean, free from visible seeds with no Insect damage, well cured (6-8% moisture content) clean storage facilities; treat storage facilities and seeds; check seeds regularly during storage (according to storage period.)

It is best to store groundnuts in their shell. Good drying of the pods to 7–8% moisture content will help to ensure that the seeds remain in good condition during storage. Never bag groundnuts for storage if the pods are still damp.

Before storing, poor, damaged, shrivelled, rotten, or fungus-infected pods should be removed. Whatever the storage container, it is important to ensure that the store is dry and that there is good ventilation so that the pods/seeds do not increase in moisture content, which would encourage fungal growth. Ideally the store should be cool, as this prolongs the storage life of the pods.

Note. Moisture is the key to safe storage and moisture content of grain is related to relative humidity of surrounding air. Safe moisture content of cereal is 13% – 15%

**How to test moisture content in grain**

* Use dry bottle with a lid.
* Put one table spoon of salt in the bottle.
* Pour a half glass of groundnut in the bottle
* Seal the lid and shake up to mix well
* Place the bottle in the sunshine for 30 minutes
* If the grain is not dry, then the moisture will be attached to the bottle wall which will therefore need more drying.

**Storage Temperature and Hygiene**

Very high temperature 66∙ºC will destroy seeds. High temperature 21-24 ºC speeds up respiration of grains. The lower the temperature the better. Stores should be kept clean at all time. Grain is dried clean and free from discoloured and low quality seed. Bags are kept off floor on wooden platform to avoid absorption of moisture. Produce be treated with pesticide before taken to the store.

**Ventilation**

Bags should be made of a material which allows the air to circulate, therefore, gunny bags are recommended. Do not use polythene or polypropylene bags as these restrict air flow and fungal growth could occur. For the same reason, do not cover bags with plastic or tarpaulin (canvas) which may also restrict ventilation and increase condensation. Bags should be stored away from the ground on wooden slats to avoid damage from dampness. If bags are stacked, a gap should be left between stacks to allow ventilation. Do not stack bags more than ten bags high.

**Contact treatments for unshelled groundnuts**

Stacking sites should be treated with insecticide dust before windrows and stacks are formed for drying the groundnuts. The surrounding should also be treated to protect the site. Groundnuts are thus protected against termites. Storage areas, containers, drums, bags and storage equipment (conveyors, etc.) should be treated before storing groundnuts. Cleaning of these areas can be followed by fumigation or spraying with insecticides.

Pesticides are applied using a sandwich technique. Seeds are dusted during bagging, and then an insecticide dust is applied between each layer of bags. Organophosphates are contact insecticides currently used. Other available products with long residual activity include Ethyl-Pyrimiphos (Actellic) Methylchlorpyriphos (Reldan). Their residual activity is low in the open air but is effective for more than 6 months.

**Fumigation**

Groundnut seeds (sorted pods or kernels) can be treated under airtight plastic, sealed silos or warehouses. Bags are arranged to form a pyramid. The base is sealed with a row of sandbags. Hydrogen phosphide (PH3) is the only authorized fumigant. It is available in tablet form and its use requires absolute adherence to manufacture’s recommendations in order for it to be effective.

Successful fumigation depends on ambient moisture, fumigant dose and duration. Fumigant dose can be reduced in airtight treatment areas with high temperature. Stored groundnuts should be regularly checked and a seed sample taken every 3 weeks to ensure proper conservation.

Physical and mechanical methods

These methods are low cost, effective and readily available to farmers. Several techniques are used, depending on the area:

Groundnuts are mixed with powdered minerals (ashes, sand, etc.) that act as  
• abrasives or physical barriers; sealed containers (silos) in which anoxic conditions limit insect development, Temperatures below (<5°C) or above (>40°C) are optimum for insect development.

**STORAGE PESTS**

**Mites**  
Are smaller than insects and appears as dusts on grain. Some feed on grains which others feed on moulds developing on grains. Mites are associated with high moisture content in stored seeds / grains.

**Insects**  
Some of the insects that damage the grain begin their attack in the field several weeks before harvest. E.g. pulse beetle. Survival of storage insects depend on temperature and moisture content (temperature >42 ºC or < 10 ºC will kill insects and moisture content below 8% will not permit insects multiplication). Damage by one insect may lead to further damage by second type of insects e.g. grain weevil destroys sound grain, its lava bores into grain and feeds on endosperm. Red flour beetle, which feeds on the grain dust, further attacks damaged grain. Saw beetle also feed on the damaged grain.

**Rodents**  
Rats and mice are most important rodents of the stored food. They cause damage by:

Consuming the nuts, contaminating with fur and urine, carry disease causing microorganism e.g. plague

The quality of groundnut is determined very much at the farm level. Good management practices like planting, weeding, harvesting, drying and storage on-farm (as set out in this manual) will ensure that the pods/seeds are marketable. A buyer will, in particular, be looking for: varietal purity (at least 95%), low moisture content (7–8%), high shelling percentage (above 55%), low level of damaged pods/ kernels (less than 17%) and no aflatoxin contamination. These are normally ideals shown on the packaging material.

**General characteristics that determine quality of groundnuts**

-Variety: Sorting should be done according to the same variety of the groundnut for uniformity in colours, sizeandvariety.  
Critical microbiological problem in groundnut / Quality and marketing  
-Premature or discoloured or spoiled grains: This gives or lowers the quality and gives a poor presentation.  
-Broken or fragmented grains: This allows the mould to use exposed material and facilitates easy spread. The mould produces aflatoxin, which is a worldwide problem because, is remains in the food even after the fungus thatproducesithasdied.  
-Moisture content: Should be dried to a moisture content of 15% (grain) and 7%-8% for pods to avoid mould growth.

**Threats to production**

Low yields in the semi-arid tropics are attributable mainly to the fact that groundnut is grown in marginal area under rain fed conditions and is subject to periodic drought.

 The crop is highly susceptible to contamination by some 20 different Mycotoxins, including aflatoxin caused by a fungus *Aspergillus flavus*. Aflatoxin is extremely hazardous to human health and is especially harmful to the physical and mental development of young children. Over time, exposure to aflatoxin-infected foods can lead to hepatitis, immune system suppression and liver cancer.

The risks associated with aflatoxin contamination have led industrialized countries to establish rigorous quality standards that often deny farmers from developing country the opportunity to export. In West Africa for example, groundnut is largely produced by women and export prohibitions have important implications for family well-being and frequently prevent farmers from purchasing resources that might otherwise be used to increase productivity.

**END**

**Sunflower (*Helianthus annus*)**



**Introduction**

Sunflower is a crop which, compared to other crops, performs well under drought conditions; this is probably the main reason for the crop’s popularity in the marginal areas of Kenya. Unfortunately the crop is particularly sensitive to high soil temperatures during emergence and it is especially in the sandy soil where it results to poor or erratic plant density.

The Sunflower plant is a major oil crop in south-west Kenya. It is a source of high quality edible vegetable oil. South-west Kenya is in the Lake Victoria region and is suitable for sunflower farming. To address constraints such as low production, research has been undertaken by KARI targeting small-scale farmers who are vulnerable to food and nutritional insecurity.

In large parts of the sunflower producing areas, the soil has acidified dramatically during the last decade. Consequently, molybdenum shortages often occur and are possibly one of the greatest yield-limiting factors. The crop is very susceptible to bird damage and for this reason; it cannot be cultivated at all in some areas. On the positive side, however, the drought tolerance and low input cost of the crop are major advantages.

The short growth season of the crop, which has the consequence that it can be planted over a period of at least three months, renders it extremely suitable for producers who make use of adaptable crop rotation and/or fallow systems. In any case, sunflower is a crop which only belongs in a crop rotation system.

**Sunflower varieties**

The sunflower crop is of various varieties but two main types exist. These are:-

**Tall varieties**

Most varieties grown in Kenya are tall with an oil content of 28%.

The tall varieties are open pollinated and can grow to a height of 5-8 ft. i.e. 1.5m-2.4m. The most grown local varieties are:-

* Hungarian white
* Kenya fedha
* Kenya Shaba
* Record
* Grey stripped
* Dark stripe
* White stripe

**Dwarf varieties**

The dwarf varieties are normally hybrids and grow to a height of 4 ft. (1.2m). They have smaller heads. The most commonly local dwarf varieties include:-

* 8998
* G101
* Pan 7352
* Pan 7369
* H8998

**Ecological requirements**

**Rainfall: -** A rainfall amount of 500-750mm annually is sufficient for better yields. Good yields can also be obtained even with less than 250mm of rainfall. The crop is drought resistant because of the deep roots. However, the crop requires rains during flowering but dry conditions are required during ripening to prevent rotting of the heads.

In areas of short rain periods, the dwarf hybrid varieties are advisable as they have a shorter maturity period.

**Soils: -** It is grown in many soil types of moderate fertility.it does well on light-rich calcareous or alluvial soils with a PH of 6.0-7.5.the sunflower plant is a heavy feeder of soil nutrients and therefore enough nutrients should be available.

**Light:-**The daylight is not critical for sunflower production especially when all other conditions are favourable.

**Crop cycle:-**Less than 100 to a maximum of 160 days

**Temperature: -** It is primarily a zero temperature crop and is more resistant to frost and drought than maize or soybean. Tropical lowlands induce premature flowering and high temperatures inhibit seed set.

**Altitude:-**The crop does well from sea level up to 2600m ASL

**Field operations /Agronomy**

The best time for planting in Kenya is from mid-June to mid-July to allow enough rain during flowering and dry weather during ripening.

A phosphatic fertilizer such as SSP at the rate of 17kg/Ha is applied in the seedbed before planting

Weed Control: - Narrow rows are favoured for the promotion of an early canopy closure, which depresses weed growth and assists as a soil conservation measure. Well managed tillage by cross harrowing or by inter-row cultivation should suffice for weed control.

The field should be free of weeds when the plants are young up to a height of 0.9m until when a canopy is formed to smother the weeds. Lodging is minimized by earthing up soil around the stems during weeding.

**Pests and Diseases**

**Diseases**

The most common diseases are:-

Stem and Head rot: White mycelium attacks roots, stem and head. Infected parts shrink and rot.

Leaf spots: caused by *Septoria helianthi*

Downey mildew: Loose white mycelia on lower surface of the leaves

White blister rust: Caused by *Cystopus tragopogonis.* white spores appear on the lower surface of the leaf. Raised pale yellow portions appear on upper leaf surface stem.

Charcoal rot: Caused by *Sclerotinia spp*. Discoloured stems at the base internal stems appears shredded

Brown (leaf) rust: Reddish brown spores on leaf surfaces

Grey mould: mase of grey mycelia penetrating into the heads causing rot.

General disease control measures include;

* destruction of crop residues,
* crop rotation with cereals and grasses,
* use of clean planting materials(seeds),
* And spraying with foliar fungicides.

**Pests**

The most common pests attacking the sunflower crop include:-

**Cutworm:** cuts seedlings at the ground level. Controlled by use of 35% EC at 1.56kg/Ha.

**Semi loopers:** Older larvae skeletonize leaves. Controlled by use of dipterex and cypermethrine

**Birds:** Eats maturing seeds. They can be controlled by use of birds scaring devices.

**African bollworm:** Eats leaves and developing seeds. They can be controlled by using dipterex 95% of 13kg/Ha or cypermethrine 1L/Ha.

**Harvesting and post-harvest operations**

Local varieties ripen unevenly hence more than one operation is needed. The crop is also prone to shattering and severe bird’s damage especially if heads face upwards. Hence, the plants should be cut when the disc florets turn brown and the backs of the heads turn from green to yellow.

Threshing is done by beating individual heads with sticks to separate the seeds.

The moisture content of the seeds should be less than 14% for safe storage of the seeds.

**Uses and Utilization of Sunflower**

* It’s mainly crushed to yield edible oil. The seeds contain 25-50% oil
* For industrial use-in soap making.it can also be used together with linseed oil in manufacture of paints and varnish.
* The residual sunflower cakes/seeds heads are used as fodder for livestock industry
* Can be used as wood fuel for cooking
* Young plants are used to prepare silage
* Can be ploughed in as green manure to improve soil fertility

**END**

**INDUSTRIAL ANNUAL CROPS**

**Tobacco (*Nicotiana tabacum*) farming in Kenya**

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**Introduction**

Tobacco is mostly grown in south Nyanza of Kenya where the land under cultivation has increased rapidly and often at the expense of the traditional food crops and livestock activities.

Kenyan tobacco farmers are struggling under the burden of credit extended to them by manufacturers. Tobacco farmers in Kenya believe that the inputs given to them as a loan in the form of seeds, pesticides and fertilisers tend to be overpriced. Farmers are losing money once deductions are made for the loan, labour, fuel and costs.

This situation did not improve over the review period. The political unrest at the beginning of the year also contributed to the situation, making it very difficult for farmers to meet their obligations.

**Plant characteristics**

* Tobacco is an annual crop which grows to a height of 1.2-2.4 m depending on the variety with a tap root unless broken through transplanting which do not penetrate deeper than 1.2m.
* It has leaves which are broader and less pointed towards the bottom of the plant with glandular hairs on the surface which secrete gums and oils contributing to the flavor of the finished product.
* When the top part of the plant is removed suckers grow on the remaining axils. The flowers are pink with many minute seeds (10,000/g) if inflorescence is left to develop.
* Tobacco is first raised in the nursery for 2months and takes 4-4.5 months from transplanting to harvesting.

**Growing zones**

Approximately 35000 small‐scale farmers grow tobacco in Kenya. In all, 15000 hectares of land is devoted to tobacco farming.BATK has a contractual arrangement with these small‐scale farmers. The company offers them crop inputs and advice, and buys leaf from them once dried (cured). The price farmers receive for their tobacco leaf is dependent on BATK’s evaluation of its quality. Usually no independent assessors are present.

Current annual production is estimated at 16,000 tonnes.

The Kenyan Government, as most other developing countries, treasures the tobacco firms because of the revenues generated by the tobacco firms through taxes remitted. In fact between the tobacco firms,  
the farmers and the government, it is the government that is the greatest beneficiary.

In Kenya, tobacco farming takes place in Western (Bungoma, Busia, Teso and Mount Elgon districts), Central (Kirinyaga, Muranga, and Thika) and Eastern (Meru, Kitui and Machakos counties). However, most of the 80% tobacco production is taking place in the Southern Nyanza region mainly in Migori, Kuria, Suba and Homa bay areas of the Nyanza region.

**Ecological requirements**

Rainfall- should be reliable but not excessive to reduce disease incidences. The crop requires 380mm well distributed rainfall during 3.5 months after transplanting.

Altitude- between 900 to 1500m ASL. Above 1500m the leaves become thick and leathery and below 900m the leaves are light.

Temperature-requires a max of 270C and minimum of 130C it is a medium altitude crop. Optimum temperatures for tobacco development are between 20 and 30 degrees Celsius.

Soils-requires light, well drained soils with good water holding capacity. Sandy loamy soils are the best. The soils should be rich in N during early stages of growth but less by the time the crop ripens because growth is reduced and leaves yellow poorly during curing. High N content also make curing difficult.

Excessive supply of chlorine leads to poor quality tobacco, cured leaves are grey with white mid ribs, and they hold moisture reducing combustibility and have unpleasant smell.

The ideal soil Ph. is 5.5-6.5

**Varieties**

Flue cured varieties include; Fire cured varieties include;

* White gold Heavy western
* Kutsaga 51
* K326
* NC 96
* G22

**Propagation and field management practices**

**Land preparation/seedbed**

Raised beds are usually 1.2mx2.3m .a fine tilth is required as the seeds are small. The seeds are best sown by mixing the seeds with water and pouring it on from a watering can with a good rose. The seedbed is gently raked taking care not to bury the seeds deep to avoid poor germination. Both types of tobacco should be established on ridge for better drainage.

**Planting season.** Traditionally, in tropical climates it has been considered that the ideal months to plant tobacco are November and December, since it results in better yield and quality and allows for rain-fed cultivation, taking advantage of the rain during this season. Late planting gives low yields and low quality due to unfavourable environmental factors and severe pests and diseases.

* Early morning or late planting in the evening protects the seedlings from direct sunlight. The planting hole should be wet. The tap roots should be kept straight during transplanting and to such a depth so that buds are at least 2.5cm above the ground.
* Tobacco seeds are very small and its germination is delicate and complicated. It is recommended that they be germinated in green houses to obtain seedlings to be transplanted in the field. Green houses should be installed in clean places, well drained and closed to water sources, preferably in new terrain.
* Transplantation is a careful process, since the young plant is very vulnerable to climate variations, to diseases and parasites. The seedlings to be transplanted must be 3 to 6 inches high, about 40-50 days after planted.

Spacing-for flue curing the spacing should be 1m between the rows and 54-59cm between the plants to allow enough room for healthy leaf growth. Fire cured tobacco should be spaced at 1mx1m since the leaves are larger.

**Gapping**

Gapping is done in 8-10 days after transplanting.

**Fertilizer application**

In flue cured is a critical factor and should be applied at 22-34kg/Ha for flue cured and 45kgN/Ha for fire cured tobacco.

Phosphatic fertilizers at the rate of 110kgP/Ha should be applied as a basal fertilizer. Deficiency causes poor ripening of the leaves.

Potassium gives good burning properties during curing hence should K2SO4 be applied.

**Topping and desuckering**

Both types should be topped (removing inflorescence) when 20% of the plant have started to flower in order to give wider leaves with more body.

Leave 16-20 leaves on each plant for flue cured and 8-12 leaves for fire cured tobacco. Topping also stimulates the growth of suckers in the axils of the leaves which should be removed at regular intervals not to grow longer than 10-13cm.

**Qn. Describe the following operations in tobacco production and state their significance.**

1. Topping
2. Desuckering

**Topping** is the process of removing flower heads either alone or with few upper leaves from the plants or is the removal of the terminal bud with or without some of the small top leaves just before or after the emergence of the flower head.

Suckering follows topping in that tobacco is as apically dominant plant and when the terminal bud or flower head is removed, lateral branches (suckers) arise and develop from the leaf axils.the suckers are then removed before attaining a 5cm length and this is known as **desuckering.**

**Significance**

1. Increase root growth
2. Decreases the top weight of the plant so that it does not fall over/lodge
3. Improves water and nutrient absorption and also facilitate diverting them to the leaves
4. Improves the size body, texture and quality of leaves and also full development of top leaves. The leaves become thicker and oily.
5. Improve yields and quality. Higher yields are achieved when both operations are done as opposed to topping alone.
6. Increases the nicotine and desirable sugar content of cured leaf.

**Weeding-** Weeds should be removed soon after they emerge.atleast three weedings are required up to when the crop is at knee height. The soil should be heaped around the stem during this time.

**Harvesting**

Tobacco leaves ripen from the base upwards. They are removed as they ripen. This process is called **priming.** A few of the lower leaves may be primed and discarded if diseased or too small.

During harvesting, in order to achieve proper curing of the tobacco leaves it is important to harvest them at the proper time of ripeness, this of course, depends on the variety of tobacco. For example, for black tobacco it is better to harvest before the stage of physiological ripeness, unlike blond tobacco which is harvested at an advanced stage of ripeness so that there is a predominance of carbohydrates. In order to obtain a good harvest, it is necessary to place the harvested leaves in a tobacco house to protect them from the environment and from losing moisture in an accelerated manner. Nor should they be piled up in warehouses for long periods of time, in order to prevent mishandling or premature cell death. They must be strong together in such a way that rings only hold two leaves at a time.

Maturity/Ripeness

Is indicated by a lightening of the colour of the leaf blade, a whitening of the mid rib and an angle of 900C between the stem and base of the mid rib. At this stage, senescence is advanced and carbohydrates are less mobile and remain in the leaves. Ripeness for fire cured is indicated by the tips and edges of the leaf turning downwards and a yellow mottling of the leaf lamina

**For flue cured,** 1-3 leaves are primed at a time. The first is taken during topping i.e. 2-2.5 months after planting. From then onwards, priming is at weekly intervals which may be longer with uppermost leaves which take longer to ripen. There are usually 6-9 priming’s.

**For fire-cured,** more than two leaves are primed at a time and only 2 or 3 operations are needed. Priming usually occurs at an interval of 2weeks.

**Curing**

Once tobacco is harvested, the leaf must undergo a real transformation in order for it to become raw material for the industry. Once harvested, tobacco leaves must first be cured, later fermented and aged.

**Flue -curing**

This is done in a carefully constructed brick stone or mud where temperatures and humidity can be controlled. It’s a quick process taking 4-6 days.it allows for oxidation of chlorophyll, causing the disappearance of the green colour and breakdown of starch into sugars. After this, the leaf is killed quickly by desiccation so that no chance for the sugars to be hydrolysed and browning cannot occur due to oxidation of phenolic compounds. The barns (structures) should be big enough to hold one days reaping/harvest.it must air tight, apart from ventilators at the top and bottom to allow flow of air inside. A metal flue (chimney of a furnace outside the barn) leads across the floor. Wood is used as fuel for the furnaces. The leaves are strung on sticks either by single string method or by double string method. Sticks are 1.2m long and are placed in the tiers.

* **Steps of flue curing include:**

1. Withering

Wood fuel provides heat for tobacco curing/dehydration. Hot air from the wood fuel circulates around the barn in the metal pipes. Temperature and humidity are carefully controlled.

Remove all surface moisture from the leaves before beginning to yellow them.it takes 12 hours

1. Yellowing

Start yellowing at temperature of between 32-40 0C and high humidity conditions .If it is necessary to open vents slightly during yellowing so that temperature is not raised.

Maintain temperature at 32-400C until all the leaves are yellowing.

Chlorophyll breaks down through enzymatic action causing yellow pigments to be visible.

1. Colour fixing

The temperature is raised to between 43-490C and ventilation increased. The colour further changes.

1. Drying of the leaf lamina

The temperature is raised to 600C and the lamina of the leaf dries. The ventilators are opened at this stage.

Lamina drying takes 36-48 hours to fix and dry.

When leaves are yellow, colour is fixed and sufficiently wilted, raise the temperatures to 600C. The lamina of the leaves dry.

Reduce ventilation towards the end of the leaf period but maintain temperatures at 1300F until all the leaves are dried.

1. Mid rib and Stem drying

Temperatures are raised to 1600F and maintained there until all stems are dried.

**Fire-curing**

Is done in thatched barns and is a longer process than flue-curing taking 4-7 weeks. The leaves are killed less quickly so that phenolic compounds are oxidized giving a brown colour. Sugars are largely hydrolyzed giving a low sugar:N ratio .the smoke here is important and adds to the brown colour and flavour. There are pits in the floor for the fires. The leaves are first yellowed, either by hanging them in the barn without a fire for 4-7 days or piling them in a heap in a shade before placing them in the barn. Then fires are lit and are kept going for several weeks. Fires should give much smoke and less heat.

**Tobacco Farming in Kenya – Challenges**

* Preliminary investigations reveal that tobacco farming is highly labour-intensive.
* Earnings from tobacco are not commensurate with the input by the farmers.
* Child labour and school drop-out are common features in the tobacco growing zones.
* During drying of tobacco leaves (curing) a lot of biomass from indigenous flora is used. This leads to deforestation and even soil erosion.
* The curing plants (barns) are designed in such a way that the farmers are exposed to tobacco smoke – potentially making them candidates for tobacco-related diseases.
* Schemes of the anti-tobacco crusaders-not supporting production and consumption

**Pests**

* **Nematodes;**

**Control**: soil fumigation

* Crop rotation

**Diseases**

1. **Brown spot disease**

It is caused by fungus Alternaria tenuis lesions appear on ripening leaves which are circular brown spots zonated with concentric rings, the midribs and stems may also be affected.

Control: early planting

-use of balanced fertilizers

- removing leaves as soon as infection is seen

1. **Anthracnose**

It caused by fungus *Colletotrichum tabacum* which causes water soaked patches on the lower leaves, the lesions may turn brown or white with dark margin.

Control: chemical

1. **Leaf curl**

It is a viral disease transmitted by white flies *Bemisia spp* and causes thickening of the veins hardening of the leaves and a downward curling of the leaf margins.

Control: destruction of crop residues

-use insecticides to control white flies

1. **Rosette/ bushy tops**

It is transmitted by aphid *Myzus persicae* which causes stunting growth and production of many small leaves and axillary shoots.

Control: use of systemic insecticides against aphids

-destruction crop residues

**END**

**FIBRE CROPS (Cotton and Flax)**

**Cotton (*Gossypium hirsutum*)**



**Introduction/importance**

* The most valuable product of cotton plant is lint. (The hairs which grow from seed coat).Lint can be spun into a yarn and is the most important plant product worldwide.
* The oil which is a by-product is extracted by heating and crushing the seed after the lint has been removed.
* Cotton seed oil is used as a valuable livestock feed.
* Linters (minor by products) which are short hairs on the seed coat are used in the upholstery industries to manufacture carpets and mats.

**Cotton Farming in Kenya:** Cotton in Kenya is grown in Nyanza, Western, Coast, Central, Eastern and Rift Valley regions, largely under rain-fed conditions. Cotton in Kenya is mainly grown by small-scale farmers in marginal and arid areas on small land holdings averaging about a hectare. It is estimated that Kenya has 200,000 small-scale farmers.

**Constraints to cotton production**

Prior to structural adjustment, production-to-market chains for agricultural commodities were  
integrated under the control of state or parastatal organizations that provided subsidized  
farm inputs, often provided advisory services, sometimes even provided credit as well as  
purchasing the commodity from farmers. However, under the structural adjustment reforms  
government support for input and output markets has been withdrawn in the expectation that  
private sector traders would fill the niche and develop these markets. In practice, the private  
sector has proved to be highly risk-averse to investing in the cotton growing enterprises linked  
to smallholder agriculture.

As a result farmers will reserve minimal resources in terms of fertiliser application and crop  
protection for cotton in preference to food crops.

**1. Policy issues**

There are also policy issues which impact on the already complex situation, such as  
price-setting for seed cotton, subsidies for inputs and access to input credit. Cotton  
farmers are very price sensitive but attempts to control the price can have a negative  
impact on the willingness of the private sector to invest in production support  
mechanism.

**2. Lack of irrigation facilities**

With the collapse of the Hola and Bura irrigation schemes which accounted for over 30% of  
cotton production in the country, cotton is mostly grown under rainfall conditions. Yields are  
adversely affected by unreliable rainfall. Where irrigated cotton is grown there is a lack of  
proper water use in irrigating cotton sometimes leading to water logging and poor crop yield.

**3. High input costs**  
Costs associated with spraying, weeding and harvesting contributed to the high cost of  
production. Pesticide costs are high and can contribute up to 51.70% of the input costs. Gross  
margins can range from KES 1,614 to KES 12,520 per hectare.  
Inadequate use of mechanisation, contributes significantly to high production costs.

**4. Competition from enterprises with higher gross margins**  
This is especially true within the irrigation schemes where horticultural produce and  
production of seed for food crops is preferred. The Bura and Hola irrigation schemes were  
revived two years ago and cotton production within the scheme is already of a low priority to  
the farmers.

**5. Inadequate availability of quality planting seed**  
A seed bulking and certified support programme was started in 2007. However, this is  
currently inadequate and requires strengthening in terms of additional trained manpower and  
financing. Investments especially on equipment for the commercial production of seed by the  
private sector is also limited.

**6. Distribution of substandard agro-chemicals**  
Substandard or entirely fake agrochemicals especially pesticides are often sold to farmers.  
The Pesticides Control Produce Board (PCPB) is not able to ensure that all products sold are  
genuine due to limited manpower.

**7.Lack of an updated quality assurance protocol and testing equipment**  
While quality assurance procedures and standards exist, lack of more modern equipment such  
as High Volume instrument (HVI) means that cotton from Kenya is of unknown quality.

**Low yields**  
The two varieties recommended for commercial production, HART 89M and KSA 81M have a  
production potential of 2,500 kg/hectare and over 4,000 kg/hectare under rain fed and  
irrigated conditions. This potential is however far from being achieved with the average yields  
being 572 kg/hectare.