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TOT Training Material of TTM_6 *Irrigation Agronomy & Development Plan*

Part III
Improved Agronomic Practices of selected irrigated crops

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TRAINING AND CAPACITY DEVELOPMENT IN WATER USE FOR IRRIGATION AND CATTLE SUPPLY IN AFAR PROJECT

Training Material for Training of Trainers (TOT)

on

TTM-6 : Irrigation Agronomy & Development Plan

Part III

Improved Agronomic Practices of selected irrigated crops

by

GENERATION INTEGRATED RURAL DEVELOPMENT CONSULTANT

In Partnership with
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1 GENERAL

Agriculture is the art or practice of cultivating land and managing livestock

Improved agricultural practices are important and productive activities that have significant impacts on the crop and agricultural input productivity. These are essential interventions in the cropping system which should be known and applied by the farmers to get higher income from their plots of land.

Major crop production practices with their specific recommendations for each of the crop are discussed briefly to provide information for future implementation.

In this manual, the basic knowledge of major agricultural activities which are common for most of the irrigated crops are described briefly to give highlight on their use and importance in the system, moreover the manual concentrates on common irrigated crops cultivated by agro-pastorals in Afar region and in the project area in particular.

Some of the activities which are listed below are considered for explanation of the agronomic practices.

Major Important farm operation

- Tillage and seedbed preparation
- Seeding and Fertilization
- Weeding and Inter-cultivation
- Plant protection
- Harvesting
- Threshing

1.1 OVERVIEW OF MAJOR RECOMMENDED CULTURAL PRACTICES

The following agricultural practices (but not limited to) can be recommended and each briefly discussed as guidance for the users.

1.1.1 Site selection

Selecting the appropriate nursery and field sites determines the success or failure of production. The following criteria will be used to select an appropriate site.

- Gently sloping surface
- Fertile, light textured and well-drained soil; well drained heavy soils can be used for leafy vegetables and tomatoes but not for root crops such as carrots and fruit trees.
- Land not previously planted with the same or related crops, to avoid build-up of diseases and insect pests

- Avoid plots that have been infested with diseases, nematodes, parasitic weeds such as orobanche
- Avoid areas with presence of roots and shade of trees, hedges and buildings.
- Proximity to dependable source of irrigation water
- Protected from strong winds

1.1.2 Land clearing

- By burning or slashing the crop residues and stalks.
- Recommended to carry out just after harvesting to clear the farm plots for further land preparation

Why we need it?
Clearing land provides more room for crops to grow and gives the plants better access to water, nutrients and sun light; reducing pest infestation

1.1.3 Land preparation:

Land preparation is the activities required to make the land ready for sowing or planting, some of them are land Ploughing (1-2 rounds), discing, harrowing, ridging (for irrigation)
It is a pre-planting primary tillage usually made by draught power, hoe cultivation and rarely by tractors. In areas, where hoe cultivation is predominant, the oxen plough is a possible land preparation system.
In areas where tse-tse fly is a constraint then low-power tractors could be proposed.
Use of mini-tractor or walking tractor, which are appropriate for smallholder farmers
Renting of wheel tractor could be recommended in areas where rental service is available.
In addition to the above mention recommendations, the development agent has to discuss or recommend the frequency of land cultivation and schedules.

1.1.4 Planting

In planning the farmers need to predetermine the planting schedule for each proposed crop; seed/seedling rates, method of planting that might be *direct sowing or transplanting; planting spacing, depth of planting, and equipment to be used* (as required),.
the planting mechanism could be

- Planting multiple seeds in one hole (not recommended for big size seeds)
- manual row planting;
- oxen-drawn planter,
- walking tractor fixed planter seed, and
- wheel tractor accessories.

What determine the choice of the planting methods?

- **Availability of man power (lack of labor tend to use broadcasting rater than row planting)**
- **Agro-pastoral experience in use of draught power to use for seed drilling)**
- **Availability and access to improved planters (fixed planter seed)**
-

Thinning and gap filling: It is removal of some plants or parts of plants to make room for the better growth, which has to be practiced sometime after sowing or planting.
Thinning ensures:

- Growing plants have adequate space
- Plants have proper air circulation which can expose the crops for pest infestation
- To have healthy plants (keep best plants for harvest)
- Use the water efficiently without computation

1.1.5 Transplanting

It is an optional planting method mostly for horticultural crops and fruit trees which maintain the recommended plant population with minimum losses at early stage. For proper transplanting planning the followings should be considered:

- Appropriateness of seedlings (health, strong and for most vegetables pencil size)
- Time of transplanting (late afternoon preferable)
- Date of transplanting,
- Watering,
- Cares required during transportation and transplanting.

1.1.6 Fertilizer application

Basal and top dressing applications are most common in irrigated farming. Pre application the farmers need to specify *the quantity, methods and schedule of application*. Basal application usually carried out during first Ploughing to get enough time to mix and decompose in the soil. If split application is required the date 4-6 true leaf emerge and/or at knee height for field crops.

In regard with organic fertilizer application, its better as early as possible, spreading manure or compost on the field and make first ploughing to mix with the soil.

1.1.7 Irrigation

Irrigation is most important input for arid areas to get reliable harvest through proper and adequate irrigation water at the required time. Efficient on-time irrigation require to have adequate knowledge on: ***When?, How?, where and how much?***

- Type of irrigation field application
- Requirement of special irrigation like pre-planting irrigation; for leaching for soil treatment,
- Depth/amount of irrigation water required
- Irrigation interval (in days)
- Critical water stress period of specific crop
- Soil moisture condition (deficit, optimal and excess)
- Schedules or turns of the particular farmers in the scheme irrigation distribution time table

1.1.8 Weeding

The information like how frequent weeding should be undertaken, method of weeding (hand weeding or with herbicide) and time of weeding in days after each weeding task are require to know to make appropriate timely weeding.
Inter-cultivation, (shilshalo) by oxen, manual or machinery to reduce weed population and pulverize soil can be elaborated in addition to above indicated activities.
The best time for the removal of weeds is before they produce flowers and seeds

1.1.9 Disease and insect pest control

Cultural, biological and chemical spraying methods and timing have to be determined to make workable planning for the farmers.
Integrated pest control is preferable and could be recommended with appropriate and specific methods ***(refer the IPM manual of this Training).*** IPM recommendation should take in to account the availability of inputs or ingredients, farmers' experience and efficiency.

1.1.10 Harvesting

Method of harvesting (picking, cutting, up-rooting), type of harvesting machinery recommended and transporting mechanisms to storage facility are issues to be considered.

Threshing and winnowing: Method of threshing, places and materials to be used have to be explained.

1.1.11 Post-harvest handling

In general horticultural products require immediate and organized distribution to avoid post-harvest deterioration in quality. Maintaining the quality of horticultural produce after harvest is very important as most of these commodities sell on "eye-appeal". A well-organized infrastructure including storage, transportation and communication facilities can facilitate quick action to collect, distribute and maintain quality of horticultural crops.

1.1.11.1 Time on field after harvest

To maintain the quality of the produce some crops need to be left on the field for some time after harvest (potato, ground nut, onion, etc). The aim is to apply some cleaning and selecting practices. Essential tools and equipment used to clean and select are sisal brush, water, trays and wooden or plastic boxes.

However, most horticultural crops require immediate packing, storage and/or transportation to market. For instance, tomato, lettuce, cabbage, green bean and so on are among the crops which need immediate action to reach to the market areas. Therefore, to harvest the produce farmers should prepare packing material, storage and transportation facility. The initial processing must be done as soon as possible after harvest to avoid loss in quality as a result of too much exposure to the sun, moisture and insects. Vegetables will rapidly loose moisture and will deteriorate when exposed to the wind or sun.

1.1.11.2 Transportation from field

Barrels, bags or bamboo baskets on the back of donkeys are the most popular forms of transport from the field to temporary storage at the farmer's home or to the market. Donkey or mule drawn carts are also used to transport vegetable and fruits from farm to marketplace. Sometimes the local assemblers also use small trucks or pickups to transport the produce.

However, most damage occurs to the produce during transportation. This is because of poor quality of transportation facility and rough roads. To maintain good quality care must be taken not to expose the produce, especially vegetables, to; too much heat and sun; Too much drying wind; and Too many bumps that may lead to damage and scratches, resulting in the crop looking bad and not attractive to customers.

Whenever possible the produce should be put in covered containers. Some materials used for covering includes;

- Dried grass, e.g. for covering tomato baskets.. This helps to keep the produce away from the sun but still allows in enough air.
- Using sisal jute bags or plastic bags for potato and onion

However, care must be taken with some crops to avoid creating moisture build up during transportation, which can lead to rotting of the produce.

1.1.12 Storage

- Most horticultural crops have a short shelf life. If certain measures are taken during storage, the shelf life can be improved. The measures to be taken should include controlling temperature, protection from direct sunlight and aeration.
- Potatoes and onions shelf life can be extended up to three months provide that the storage is clean, dry, well aerated and cool. Farmers individually and/or collectively can prepare temporary shelter or permanent storage that assist to extend the shelf life of their produce.
- The temporary shelter can be on the farm fields and constructed easily from local materials such as bamboo, mesh wire, wood or sisal.

Farmers must take measures to protect the produce from pests and rodent attacks. Fungus and rats are the most common pest and rodent respectively.

2 ONION

2.1 LAND PREPARATION

The bulb grows quickly and becomes large under optimum land management situation, particularly if the soil is light, not too moist, rich in humus and free from weeds. If the soil is very moist, the bulb may rot. In a well- tilled soil, the water drains fast creating well aerated rhizosphere, which calls for deep tillage. Depending on the specific environmental conditions the land should be well prepared; ploughed 2-3 times at depth of 20-30cm. After the field is well leveled furrows should be prepared at a spacing of 40cm for irrigation. This should be followed by pre- irrigation one or two days before transplanting.

2.2 TRANSPLANTING

- Seedlings will be ready for transplanting to the permanent field after 40 - 50 days of stay in the nursery site, or when the seedlings develop 2 to 3 true leaves /at 12 to 15cm height/;
- Transplanting of seedlings preferably be done in the morning and late in the afternoon in order to avoid wilting of seedlings;
- It is necessary to irrigate the seedbed two days before transplanting for ease of uprooting seedlings and to minimize damage to roots;
- Uprooting of seedlings should be done very carefully in order not to damage the roots;
- The recommended planting system for hand cultivation is by making flat top ridges with furrows between the ridges;
- Plant double rows on the flat ridges 20 cm apart and the spacing between double rows is 30 to 40 cm and spacing within the row is 10 to 15 cm;
- Leaves and roots of seedlings should not be trimmed;
- Seedlings must be planted in the soil below the surface but the base of the seedlings should not be more than 2 to 3 cm deep in the soil;
- Irrigate the newly planted seedlings immediately after transplanting;
- After 7 days of transplanting, it is necessary to carry out replanting in places of missed seedlings; Do not earth up the onion plants when you cultivate; if you uncover the bulb, it won't grow well.

2.3 FERTILIZER APPLICATION

Onions prefer light but fertile soils. It is best to grow onions after leafy vegetables such as lettuce and the like. Leafy vegetables commonly add more organic matter to the soil but they also do not use all the nutrients in the soil. 200 kg/ha DAP or 242kg/ha NPS is applied fully as a basal application in the form of band placement in order to avoid loss through fixation. 100kg/ha Urea fertilizer is applied in a split form, with half of it applied 15-20 days after transplanting, while the rest 45-60 days after transplanting. It is recommended to covering the fertilizer with soil, but also application of irrigation water immediately after fertilizers are applied is essential.

2.4 IRRIGATION

The most common irrigation methods for onion crop are furrow. Onion, as most vegetable crops, is sensitive to water stress. Onion is shallow rooted crop, not more than 30cm deep and it needs frequent but light irrigations. For optimum yields, the soil water depletion should not exceed 25% of the available soil water. When the soil is kept relatively wet, root growth is reduced and this favors bulb enlargement. Irrigation should be discontinued as the crop approaches maturity to allow the tops to dry out, to prevent a second flush of root growth and avoid problems of curing.

The crop is very sensitive to water deficit during the yield formation period, particularly during the period of rapid bulb growth, which occurs about 60 days after transplanting. In order to achieve large bulb size and high bulb weight, water deficit during the yield formation period /bulb enlargement/ should be avoided. Irrigation should be scheduled by observing soil moisture level, beyond observation of the crop. In the initial growth stages, up to four weeks after transplanting, it will be necessary to irrigate every ***4- 5 days*** interval, which could be prolonged to every ***5 to 7*** days interval then after. Over irrigation sometimes causes spreading of disease such as downy mildew and white root rot. Irrigation should be discontinued 15 to 25 days before harvest.

2.5 HARVESTING

- Onion can be harvested within 80 to 100 days after transplanting;
- Bulbs are ready for harvesting when 75 % of the tops are dry and falls on the ground, but before the foliage has dried down completely.
- When the crop is matured for harvesting it is advisable to harvest using appropriate hand tools such as forks and care should be taken not to damage the skin;
- Bulbs should be harvested before the tops are completely dried up, otherwise the bulb will decay on the root;
- It is best to lift onion bulbs, when it is not raining, so that they will not rot;
- In the dry season, it is possible to leave the fresh harvest bulbs on the field for at least a week period so as to dry them well.
- It is advisable covering them with a little grass or straw or with its own leaves in order to protect them from strong sunlight and cold weather. This is technically called curing.
- Once it is dried, detach the bulbs from the tops leaving at least 1- 2 cm of top.

Table 2-1: Released onion varieties

Character.	Adama Red	Melkam	Red Creole	Bombay Red	Nasik Red	Nafis
Leaf color	Medium green	Dark green	Light green	Dark green	Deep green	Deep green
Leaf arrangement	Erect	Erect	Medium	Medium	Erect	Erect
Bulb size(g)	60-80	70-90	80-100	85-100	85-100	100-130
Bulb shape	Flat globe	High globe	Thick flat	Flat globe	Globe	Globe
Bulb skin color	Dark red	Medium Red	Medium red	Light red	Medium red	Medium red
Bulb flesh color	Reddish white	Reddish white	Reddish white	Reddish white	Reddish white	Reddish white
Maturity(days)	110-130	110-130	130-145	<120	90-110	90-100

TSS%	10-13	10-12	11-14	9-11	10-18	10-18
Dry bulb q/ha	350	400	300	300	300	400
Seed set	High	High	Resistant	High	High	High

2.6 PROPER HARVESTING

Harvesting should be conducted when the leafy green tops begin to yellow and eventually collapse at a point a little above the top of the bulb. Therefore, knowing the appropriate time of harvesting is important as maturity of product determines the duration or storage time

2.7 PROPER POST-HARVEST HANDLING

2.7.1 Selection and grading

All damaged or decaying onion bulbs should be discarded. Onions with thick necks should be put aside for immediate use because they will not store well. Market requirements will determine whether onions need to be size graded or not. Retailers in local markets will normally do their own grading when making up lots for sale. If the onions are to be made up into strings for storage or sale, it is an advantage to separate them into sizes so that the bulbs will be more or less uniform in size in any string. This makes the stringing operation easier and gives a better appearance to the finished product.

2.7.2 Post-harvest treatment

The only post-harvest treatment required for the long storage of bulb onions is a thorough curing of the bulbs (Fig. 2-1). Curing is a drying process under shade from 3-5 days intended to dry off the necks and outer scale leaves of the bulbs to prevent the loss of moisture and the attack by decay during storage. The curing of dry bulb onions is carried out immediately after harvest. Under dry warm conditions, harvested onions are left in the field for a few days until: the green tops; Outer skins and Roots are fully dried

The outermost layer, which may be contaminated with soil, usually falls away easily when the bulbs are cured. This results in exposing the dry under-layer, which should have an attractive appearance. If onions cannot be dried in the field, they can be collected in trays, which are then stacked in a warm, covered area with good ventilation.

Figure 2-1: Properly Curd Onion

Curing prevent disease infection and improve its storage life. It improves yield and quality in terms of skin color and its retention Root and leaves are properly trimmed and graded it can be transported to markets or kept in storage

Drying the outer skins of bulbs reduces decay and water loss. Roots damaged during harvesting are a common entry points for decay and water loss unless they are dried quickly.

2.7.3 Packaging

For bulk marketing, the tops of onions are removed when they are thoroughly cured and the necks are quite dry. Onions may be made up into strings. This can be 5 kg to 10 kg for onions (Fig. 2-2). This is, however, a labor-intensive operation suited to small-scale production using family labor.

Figure 2-2: Packaging materials for market

2.7.4 Storage

The first requirement for successful storage of dry bulb onions is that the cultivar chosen should have the right characteristics for long-term storage.
The principal needs are:

- The cultivar should have a long dormant period;
- it should be a cultivar which forms a strong outer skin when fully cured; brown- and red-skinned cultivars tend to be better in this respect;
- the bulbs put into storage should be disease-free; the most important storage disease is neck rot, which is controlled by dusting the onion seed before planting with binomial fungicide at the rate of one gram active material per kilogram of seed.

The storage environment must be dry and well-ventilated. Optimum storage temperatures must be the lowest available under ambient tropical conditions. At higher temperatures, onions will sprout in storage (Fig. 2-3). Onions stored in a damp atmosphere will develop roots.

Onions can be stored in bulk in insulated stores, with fans for cooling the onions using cold night air. This method is used where large tonnages are to be stored. Small-scale growers can use naturally ventilated stores made from local materials. The onions can be stacked in trays or in layers on slatted shelves. Where small amounts are to be stored, the stringing of onions in 5 kg to 10 kg lots and the hanging of the strings in a well-ventilated dry location is a very effective storage method. Dried onions can be stored in cold storage at 0-5 ^{o}C, 65-70% Relative Humidity, up to 8 months. Storage of Onion consumption is the same as to potato storage for seed (DLS).

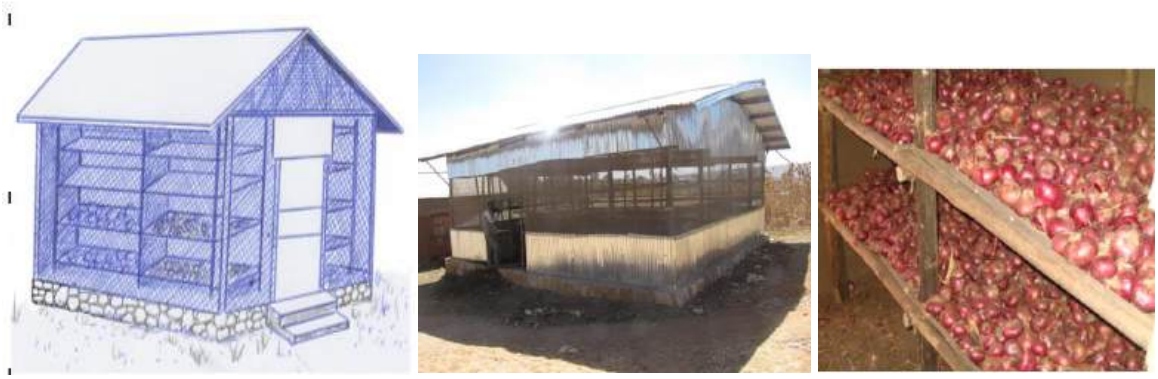


Figure 2-3: Storage facilities for onion

2.8 ONION SEED PRODUCTION

Onion is a biennial crop that takes two seasons to produce seeds. In the first year, bulbs are formed and in the second year stalks develop and seeds are produced. It requires cool weather during its early development and early growth of the seed stalk. Most varieties bolt readily between 10 to 15°C. The ideal temperature for mother bulb production is 18 -24°C day and 10-12°C night temperature.

Dry conditions are required for seed maturity, harvesting and processing. The number of stalks per plant may vary from 1 to 20, depending on the variety, size of mother bulb and time of plating. The number of flowers per umbel varies considerably from 50 to over 2000. Opening of flowers usually continues for a period of about two weeks and onion plant may be in bloom for over 30 days.

2.9 POLLINATION:

Onion is cross pollinating crop and efficient pollination depends largely on presence of insects such as honey bee, flies in the area and their activity at flowering time. It is essential to ensure that there is sufficient number of pollinating insect including honeybees to achieve the full potential of onion seed and consequent higher seed yield.
***Isolation**:* the minimum isolation distance between different cultivars is 1000m. Shorter distance may be used if the cultivars have the same bulb color.

***Rouging**:* rouging can be made before bulb maturity and during sorting of bulbs for replanting. Removing plants with off-type foliage, bulb color, early bolting, late maturing, non-typical bulb shape, color, size, early bolters, bull neck, bottle-shaped, split, damaged and diseased ones is important.

2.10 METHOD OF SEED PRODUCTION

Among the two methods of seed production in onion the most commonly used method is the bulb-to-seed method. This method has the advantage of maintaining seed quality, allowing selection of bulbs of appropriate size, uniform, typical color, shape, easily decaying, free from diseases and physical damages. It helps to produce several stalks per bulbs and hence gives higher seed yield. This method takes 10-12 months to produce seed. Under Semi-arid Rift Valley conditions, the bulb is grown from February to June and typical mother bulbs will be selected and stored for one to two months and the bulb will be planted in the cooler period (early September to October). The seed to seed method lacks the above mentioned merits. It also produces less flower stalk per bulb and takes 7-8 months to produce seed.

2.11 HARVESTING AND CURING OF BULBS:

Well-matured bulbs should be harvested. After harvesting, the bulbs should be trampled leaving a half inch neck. Before storage a thorough selection and curing of bulbs should be done. The time required for curing depends largely on weather conditions and may take three to four weeks.

2.12 STORAGE OF BULBS:

The place where bulbs need to be stored should be cool or have ventilation. Before storage, bulbs need to be well dried and cured. The storage temperature influences seed yield; an optimum temperature of about 12°C is best for storage of mother bulbs. Plants from such bulbs produce early and heavy yield than those grown from the bulbs which have been stored at higher or lower temperature.

2.12.1 Bulb selection:

Bulbs with typical color and shape of the variety in question are selected. Medium size bulbs (5-6cm) are then selected and stored until planting. Bulbs which are white, damaged, twins/ split and very small, infected by disease, doubles and long thick-necked bulbs are discarded and only true-to-type bulbs are selected. The seed yield is affected by the size of the bulb, the bigger is the bulb size the higher is the seed yield.

2.12.2 Mother bulb planting:

The optimum mother bulb planting time is between August and October. August, September and October bulb planting can give higher number of flower stalks and seed yield. Double row planting of 50x30x20cm with 125,000 bulb per hectare (80 to 90q/ha) should be used for Semiarid Rift Valley climatic condition. Onion can also be planted in single row in ridge with a similar spacing 50cm between rows and 20cm between plants for ease of weeding and pesticides applications but there could be yield reduction. Bulbs are planted 2 to 3 cm deep.

2.12.3 Harvesting and threshing

The seed is harvested when the fruit opens and exposes the black seed. A field is considered ready to harvest when about 10 percent of the heads have black seeds exposed however, it is better to harvest mature umbels when about 50% black seed is exposed on an umbel. At this stage, practically all the seed is well matured to give a good germination. Two to three pickings may be necessary to harvest the heads. The seed heads with a small portion of the stalk attached are cut with sharp knife. When cutting the umbel are supported in the palm of the hand and held between fingers to avoid seed loss. Seed heads/umbels after harvest are thoroughly dried on canvas and putting under shade or in the morning or late afternoon sun for few days. While seed extraction there should not be any damage to seed. Seeds can be threshed by mowing or rubbing of dried umbels and then cleaning the seeds by winnowing followed by pure seed separation by floatation. The winnowed and unclean seed be put in a bucket and soaked with clean water and left for 3-5 minutes in the water. Then pure seed separated from light seeds and other trashes based on their weight after 3-5 minutes soaking; heavy seeds sinks and poor quality seeds and chaffs floats.

Figure 2-4: Onion umbel drying, threshing and separating seed from chaffs

2.12.4 Seed yield & Storage

Seed yield is greatly affected by variation with cultivar and growing conditions. In average 8-12q/ha is obtained at Semiarid Rift Valley condition.

Seed should be stored in porous materials such as cloth or paper bags or similar materials in dry and aerated conditions at 7-9 % moisture. The seed moisture could significantly affect seed quality. If seed moisture content is high, normally it loses its viability at faster rate.

3 TOMATO /LYCOPERSICUM ESCULENTUM – L/

CROP Varieties

The recommended varieties under irrigation are:

- Money maker: long maturing variety which requires staking and suitable for fresh mark:
- Roma VF, which does not need staking/ suitable both for processing and fresh market/
- Melka shoal and Melka salsa both for processing and fresh market.
- Sirinka I: LGP 95-100 and yield 204 qt/ha
- Woyro; 100-120 LGP and yield 159 qt/ha

3.1 NURSERY SEEDBED PREPARATION AND MANAGEMENT PRACTICE

The tomato seed is generally sown in nursery plots and emergence is approximately within 10 days. Seedlings are transplanted to the permanent field after 35 to 40 days. Adding of 200 g of DAP and 100 g of Urea during seedbed preparation, preparing of the seedbed for sowing, sow the seeds in 1cm depth in rows, leaving approximately 10-15 cm between rows and 5 cm between plants; mulching of the bed immediately after sowing with thin layer of grass or straw is essential and 250-300 g seeds per hectare is sufficient.

Land preparation

Tomatoes need a deep soil and must be tilled fairly deep. The permanent field should be ploughed at 25-30 cm depth and cultivated with optimum frequency. The soil of the tomatoes field should be prepared several weeks before transplanting.

Then after the field is well prepared it is possible to make furrows at 60 cm width and maintain a distance of 90 cm between each furrow or 50 cm furrow width and keeping 100 cm distance between furrows.

3.2 PLANTING

Among the commonly cultivated and recommended varieties of tomato; planted using a recommended planting distance of them is 20 cm between plants within the rows and 140-150 cm between row of which the 100 cm is the size of the flat bed and the 50 cm is the furrow width through which irrigation water is applied and planting is taking place in single row using one side of the ridge approximately 10 cm from the edge of the bed.

3.3 FERTILIZER APPLICATION

The tomatoes are responsive for both nitrogen and phosphors fertilizers. Therefore, it is recommended to apply 150 kg/ ha of DAP during land preparation or at planting time and 100 kg/ha of Urea half at the time of planting and the rest half 45 days after transplanting by applying in both sides of the plant in a row and incorporate it immediately with the soil, then

irrigate the field. I there is a possibility to get organic manures /add 100-200 qt/ha of manure 2 to 3 months before transplanting and thoroughly incorporated with the soil.

3.4 STAKING

Whatever, the method is used; it is essential that the stakes should be strong enough to support the mature, fruit laden crop. The stakes should be fairly strong and about 1.5 m high. When the plant is growing about 40 cm, it is the right time to tie it to the stakes with rope or other material.

3.5 CULTIVATION AND EAR THING UP

Cultivation consists in moving the surface layer of the soil without turning it. About three such operations are required to bring plants to the centre of the bed before the shoots start to hang into the furrows. Earthen up in the case of tomato can be used to support the crop or to stimulate development of adventitious roots from the stem. Therefore, first round earthen up activity is done during fertilizer application, approximately 45 days after transplanting and the second round earthen up could be done before flowering.

3.6 MULCHING

- Cover the soil between the plants with cut herbage or leaves to keep the soil moist and depress weed growth, particularly in areas with water scarcity;
- It avoids dirtying of the leaves and fruits during watering;
- The mulch must not be too thick, in order not to affect breathing of the soil.

3.7 WATER REQUIREMENTS

In this regard, the highest yields of salad tomatoes are obtained by frequent, but light irrigation is more appropriate with the last irrigation applied long before harvest. The crop is most sensitive to water deficit during and immediately after transplanting and during flowering and then followed by yield formation. For high yield and good quality of produce, the crop needs a controlled supply of water throughout the growing period.

3.8 IRRIGATION SCHEDULING

When water supply is limited, application for a salad crop can be concentrated during periods of transplanting, flowering and yield formation. Irrigation frequency will vary according to soil type and weather conditions in the range of 7 to 15 days. Therefore, apply irrigation water every 4-5 days for the first 4 weeks and every 10 days then after.

3.9 CROP PEST CONTROL

Very serious crop losses occur in tomatoes through failure to control diseases and pests. Therefore, it is recommended to produce tomato during the dry season under irrigation to minimize the risk of disease infestation and reduce related yield losses.

Disease control

Many diseases attack roots, leaves and fruits of tomato plant. The major diseases attacking tomatoes are; early blight /*altermaria solani/ and late blight* / *phytophthora* //, *septoria leaf spot/ septoria lycopersici/* powdery mildew /*leveilula taurica/* .bacterial and Fusarium wilt.

The following are the recommended practices for the control of different diseases on tomatoes: (1) Seed treatment with fungicides; (2) Use disease free seeds and resistant varieties for planting; (3) Rouging of infected plants and burying them deeply in the soil; (4) Seed should be sown in correctly-spaced line and watering of young plants in the seedbed should be completed before late afternoon so that they do not remain wet overnight; (5) Following a four year crop rotation cycle with cereals and pulses and don not grow tomatoes next to cucumbers, potatoes or tobacco, which may have the same diseases; (6) For the control of blight spray with 3 kg/ha rate of ridomyl (0.23%) or maneb or zineb by mixing with 500 liters of water immediately after the disease is observed and spray in a week interval;

Insect pest control

Tomato fruit worm or cotton bollworm /*Heliotbis armigera/ leafbopper, whitefly/ Bemisia tabaci/, cutworms and stinkbugs* are the major insect pests that attack tomato very seriously.

Damage; Leaves are damage and flower-tiusses are cut off, but the most serious damage is that caused by penetration of the fruit by the caterpillar of tomato fruit worm, which may destroy several fruits in succession. When fruits are attacked in the very young stage they generally fall down. For the control of Tomato fruit worm or cotton bollworm the following alternatives could be taken into account; (1) Deep ploughing and exposing the eggs and pupae to their natural enemies and unfavorable weather conditions; (2) Destroying plants that serve as alternative food sources; (3) Spraying wit 21/ha of endosulfan 35 % E.C or 1.5 kg/ha of car aryl 85 % W.P; (4) Endosulfan 25 % U.L.V w 3 liters per hectare directly without mixing with water; (5) 50-70 g per hectare of hypermetric 10 % E.C mixing with 500 lit. of water. The spraying should be performed before flowering and ripening of fruits.

Nematodes: Tomatoes are especially susceptible to root knot nematodes. The nematode induces the development of irregular swelling or knots on the roots. The water and nutrients uptake from the soil is disturbed and the plant develops poorly. For the control of nematodes; Use resistant varieties, roughing of infected plants, destroying plant residues after harvest, keeping crop rotation.

3.10 HARVESTING

- Tomato will be ready for picking after 80-100 days of transplanting depending on the cultivated variety and climatic conditions of the area;
- Whereas for fresh marketing the fruits should be picked up before they are fully ripen, but for local markets, pick at the hard ripe to pink stage;
- For processing purpose /canning and paste/ it is important to pick up the fruits at their full maturity stage. When they are ripe, red all over;

- It is best to pick up tomatoes during the day, because wet tomatoes are not keeping well;
- Keep out the harvested fruits of sun; ripen best in dark;

Post-harvest handling: It includes grading, packing and storage. Grading should be done on the basis of size, shape, stage of maturity and other characteristics such as clean lines, freedom from diseases, insect or mechanical damage free of foreign material.

4 PEPPER /CAPSICUM ANNUM/

Pepper is economically important crop both for home consumption and for marketing and it is one of the most important crops for cash generating to farmers;

4.1 VARIETIES

Hot pepper varieties recommended are Bako local and MarakoFana. The varietal characteristics of Bako local are; red with thin skin, highly pungent and the size slightly less than MarekoFana. It is short maturing variety as compared to MarekoFana. But the variety Marekofana characterized by deep red colour of the fruit, long fruit, and thick skin and pungent as well. Due to thick skin this variety is, particularly suited for processing plants of spices.

4.2 SEEDBED PREPARATION AND SOWING

addition to the recommended practices discussed under general consideration for vegetable growing (discussed in this appendix) the following need to be undertaken under pepper: (1) preparing the seedbed using mixed soils in a ratio of 3:2:1 soil, manure and pure sand: (2) The total area required to raise seedlings sufficient for 1 ha is 300 m^2: (3) The distance between beds is 40-50 cm; distance between rows on the seedbed is 15 cm and the distance between plants when it is sown on seedbeds is from 2 to 4 cm; (4) A total of 600 g of seeds/he are required and a depth of 0.5-1 cm should be maintained for sowing.

Land preparation: The permanent field should be ploughed frequently and leveled, then make furrows or ridges by maintaining 75 cm distance between rows;

4.3 TIME OF PLANTING

Under rain fed condition during the main rainy season it is necessary to plant pepper starting from mid of April to first half of May. However, under irrigation condition it will be very important to plan planting of pepper by taking into consideration factors such as; season of high market demand, harvesting period for the main season crops and frost free periods.

4.3.1 Transplanting

- Seedlings of 15 to 20 cm are transplanted in the field, this is coinciding with 25 to 35 days after sowing at nursery beds;
- Prior to transplanting, seedlings need to be hardened;
- Seedlings are sometimes topped 10 day before transplanting to encourage branching.

4.3.2 Planting

Under irrigation condition, it is planted in double rows on flat-topped ridges. Double row spacing is 40 cm and the spacing between double rows is 80 cm. Spacing within the row is 40 cm. plant population estimate per hectare is about 42,000 plants. Three to five years should elapse before

planting pepper on the same field in order to avoid the buildup of insect pests and diseases and reduce their attack.

4.4 WEED CONTROL

Pepper is susceptible to weed competition, particularly at the early stages of growth. Therefore, the field should be free of weeds. The first weeding will take place after 20 days of transplanting and the second one after 40 days. It is also important to weed the field at least once just before flowering.

4.5 FERTILIZER APPLICATION

- Apply 100 kg/ha of DAP during land preparation;
- Split application of 100 kg/ha of Urea is recommended. The first will be applied after 20 days of transplanting and the second half at flowering and incorporate with the soil immediately;
- If the soil so fertile, application of Urea may not be required;
- Irrigate the field after fertilizer application;
- Recommended to use decomposed compost or well-rotted manure.

4.6 WATER REQUIREMENTS

The total water requirements are 600 to 900 mm. For high yields, an adequate water supply and relatively moist soils are required during the total growing period. In particular, the period at the beginning of flowering period is most sensitive to water shortage and soil water depletion in the root zone during this period should not exceed 25 %. Water shortage just prior and during early flowering reduces the number of fruits.

4.6.1 Irrigation scheduling

For optimum yield levels the soil water depletion in most climates should not exceed 30 to 40 % of the total available soil water. Due to low depletion level light irrigation applications are required. Irrigation frequencies of 5 to 7 days interval are common, particularly in the early growth stages but at latter growth stages it might extend up to 7 to 10 day's interval.

4.7 CROP PEST CONTROL

4.7.1 Disease control

Different plant diseases attack pepper. Bacterial leaf spot /Colletotrichumcapsici/.Phytophtora. powdery mildew /leveilulafaurica/, bacterial wilt /pseudomonalsolanacearum/ anthracnose/ colletotrichumnigrumi/ and mosaic virus are among the major diseases that attack pepper.
Symptoms of powdery mildew: chlorate blotches on the upper side of the leaf and powdery blotches on the lower side. The recommended control measures are; (1) use disease free seeds

for planting; (2) use disease resistant varieties; (3) keep strictly a 4 year cycle of crop rotation with cereals, pulses and fodder crops; not planting pepper after eggplants, tomato and potato on the same field within 2-4 years' time; (4) avoid host plants that serve for disease transmission; (5) rough out infested plants and buried them; (6) avoid contamination and wounding of fruits; (7) for leaf spot or phytophtora spray copper oxychloride 0.5 % 50g/ha mixed with 10 liter of water; (8) for controlling of powdery mildew spray with kocide 0.2 % 20g mixed with 10 liters of water.

4.7.2 Insect pest control

Aphids, leaf miners, cutworms, fruit fly, false codling moth, Halitosis armiger and lesser armyworm are among the major insect pests that attack pepper. Developing maggots with the infested fruits can be collected and killed, as soon as attacks are observed apply sprays of dimethoate, malathion, or trichlorophon, but during the harvesting period use only malathion and/or trichlorophon.

4.8 HARVESTING

- For dry or hot pepper it is important to harvest fully matured and reddish pepper;
- Fully matured and picked pepper can be kept in the field on well-prepared clean area for sometimes in order to dry it completely;

Figure 4-1. Pepper ready for harvest.

For fresh use harvest at the green stage (Fig. 4.1). Store the harvest in a cool, shaded and, dry place until they are sold, for dry or powder use at leathery stage. Pepper is commonly dried after harvest and sold as dried fruits or ground into powder. For dry pepper, the most important consideration is to preserve the red color of the mature fruits.

4.9 POST-HARVEST HANDLING

Harvested peppers should be placed in the shade immediately after harvest and cooled. If refrigeration is available put it in as soon as possible to lower the field-heat. The use of

perforated film carton liners or perforated plastic bags increase storage life, although it may inhibit proper cooling and may encourage diseases. Before final packing for market peppers should be selected for uniform maturity, color, shape, size and for freedom from defects (sunscald, mechanical or insect damage or decay).

Cooling and storage

Immediately after harvesting, peppers should be cooled to 7 ^{0}C. If they are allowed to remain at high temperature for more than 1 to 3 hours they will begin to show signs of shriveling, shrinkage, softening, accelerated ripening and color changes.

Peppers are also sensitive to chilling injuries. If kept at temperatures below 4 ^{o}C, they may show signs of softening, pitting and a predisposition to decay. Peppers are sensitive to ethylene gas produced as a natural by-product of ripening, by some fruits and vegetables (such as tomatoes, apples bananas and avocadoes) which should never be stored and shipped together with peppers.

Figure 4-2: . Harvested and ready for market

Figure 4-3: Pepper prepared for dry or powder

5 MUNG BEAN

Mung bean, *Vigna radiata* (L.) Wilczek is a warm season legume and it is a native of India and is still grown in large acreage there. Mung beans are grown widely for use as a human food (as dry beans or fresh sprouts), but can be used as a green manure crop and as forage for livestock. It is an early maturing crop and also moderately tolerant for drought and has a great potential for semi-arid areas with short growing cycle. In Ethiopia the crop is grown in Shewa Robit, Gofa, Konso and Omo valley. it is consumed as boiled grain, stew and soup. The special feature is good yield, better nutritive value, earliness (65 days from sowing to maturity) for drought escape and ability to stimulate striga without being parasitized.

5.1 GROWTH HABITS

Mung beans are in the legume family of plants. They are warm season annuals, highly branched and having trifoliate leaves like other legumes. Both upright and vine types of growth habit occur in mung bean, with plants varying from one to five feet in length. The pale yellow flowers are borne in clusters of 12–15 near the top of the plant. Mature pods are variable in color (yellowish-brown to black), about five inches long, and contain 10 to 15 seeds. Self-pollination occurs so insect and wind is not required. Mature seed colors can be yellow, brown, mottled black or green, depending upon variety. Mung bean germination is epigeal where the cotyledons emerge from the ground.

In the past different set of mung bean accession and varieties were mainly introduced to Ethiopia from India and the Middle East in the early 1970s. They were evaluated for adaptation, yield and disease resistance. Among the different varieties tested M-1134, M-409, M-109, M-76, M61 and M-140 ex Gode were found to be suitable for the dry land areas.

Past research results are showed that the crop has high potential in the dryland areas of the Kobo and other sites.

Table 5-1: Mung bean varieties and management practices for the Kobo area Varieties

	Sowing Date	Days to Maturity	Population Density	Spacing (cm)	Potential Yield (q/ha)
Early varieties					
M61	End June-mid July	65-70	222,222	45 x 10	15-20
M76	End June-mid July	65-70	222,222	45 x 10	15-20
M140	End June Mid July	65-70	222,222	45 x 10	15-20
Late varieties					
M1134	Mid June	90-105	222,222	45 x 10	30-40
M-109	Mid June	90-105	222,222	45 x 10	30-40

5.2 SUITABLE ENVIRONMENTS

Mung beans are a warm season crop requiring 65–120 days of frost free conditions from planting to maturity (depends on variety). Adequate rainfall is required from flowering to late pod fill in order to ensure good yield but it can also be produced if there is short rain season. High

humidity and excess rainfall late in the season can result in disease problems and harvesting losses due to delayed maturity.

Mung beans (if proper varieties are used) are adapted to the same climatic and soils conditions where soybean, common bean and cowpea can be grown. Mung beans are responsive to length of daylight so short days hasten flowering and long days delay it. Varieties differ in their photoperiod response

5.3 CULTURAL PRACTICE

5.3.1 Land Preparation

The soil should be tilled to remove weeds and to prepare a seedbed which will provide good seed-soil contact. On average the land should be plowed 2-3 times before planting. The final seedbed needs to firm with a surface free of clods and debris to allow a good distribution of seeds. If moisture is short, keep pre-plant tillage to a minimum to prevent drying out the top 5 or 7cm. As mung beans have relatively smaller seed size, they need fine seed bed and should be planted shallow.

5.3.2 Planting time

Mung bean is produced both in Bulg and Mehir in Shewa Robit and South areas. Table 4 shows different planting time for different areas. Too late planting results in bloom and pod fill during the hottest and driest period of both Bulg and Mehir season since the crop is planted at the end of the season. In some areas mung bean is planted as a second crop after cereal is harvested. If this is done planting should occur immediately after the grain harvest with a minimal disturbance of the seedbed

5.3.3 Sowing Method

Mung beans can be planted both in broadcasting and row planting. If possible, row planting is preferred for easier weeding. Row planting can be done by hand or seed drill. If broadcasting is used the seed can be covered by ploughing with an ox plough or by disc harrowing. Depending on seed size, soil type and climate, the proper range for seed depth is 3.81 cm. If the surface layers are dry this depth can be increased to 5 cm if the soil type is not crust easily. The seedlings of mung bean can have a hard time breaking through a thick crust and crop establishment will be reduced. Broadcasting is the most commonly used by farmers whereas row planting is used by commercial farmers

5.3.4 Seed Rate

Spacing for row planting is 30cm between rows and 10 cm between plants and the seed rate for row planting ranging from 25 to 32 kg/ha.

Soil

Mung beans do best on fertile sandy, loam soils with good internal drainage. They do poorly on heavy clay soils with poor drainage. Performance is best on soils with a pH between 6.2 and 7.2

Mungbean has phosphorus, potassium, calcium, magnesium and sulfur requirements similar to other legumes which must be met by fertilizer additions if the soil is deficient in these elements

5.3.5 Fertilizer

As a legume that fixes its own nitrogen, mung beans do not need much nitrogen fertilizer. Nitrogen and phosphorous needs have not been studied for mung bean in Ethiopia. If other crops like common bean respond to phosphorous in the area apply around 50-100kg DAP/ha during planting. The small amount of nitrogen will help the plants to get a good start. When the plants are deficient in nitrogen they show leaf yellowing, at this moment, 50-100kg urea/ha could be applied as top dressing before flowering. Mung beans require phosphorus, potassium and certain micronutrients at levels similar to other field beans. The amount to add as fertilizer should be based on soil test levels.

5.3.6 Intercropping

Some preliminary sorghum/mungbean intercropping trial was conducted at Kobbo to identify the influence of growing mung bean in association with sorghum (Kidane et al, 2003). The results indicated that sorghum yield can be significantly increased by growing mung bean as an intercrop. The research results show that when sorghum is intercropped with mung bean, the practice gave an extra yield of 495kg/ha of sorghum. The other advantage of this crop is that the reputed ability of mung bean to stimulate striga germination reduced the parasitic load on sorghum plant.

The importance of reduction in weed infestation with mixed or intercropping is also well documented (Reddy and Kidane 1993). For example, at kobo striga infestation was reduced when mung bean was intercropped with sorghum.

5.4 WEED CONTROL

Weed control is one crucial factor among others, which affects the yield of mung bean. After planting, weeding is required once every 15 days, either by ploughing or chemicals. Herbicides such as alachlor at 1.5 kg a.i./ha and chloramben at 2.5 kg a.i./ha are applied as a pre-emergence spray to control weeds. Hand weeding at about 30-40 days after planting is beneficial

5.5 DISEASES

Powdery mildew

Occurs under cool temperature (20-26 ºC) and is favored by cloudy weather. It can cause up to 40% yield loss. In the early stage the disease appears as light yellowish irregular spots on leaves which turn brown quickly. A powdery mass grows over the spots covering the entire leaf surface. To control powdery mildew, planting of resistant cultivars is good control method. If using powdery mildew-susceptible cultivars, spray ethirimol at the rate of 200 ml a.i./ha beginning 3 weeks after emergence.

Cercospora leaf spot (CLS)

Commonly attacks mung beans in the tropics. The disease is recognized by the appearance of leaf spots that are circular to irregularly shaped with grayish white centers and reddish brown to dark brown margins. It can cause yield losses of up to 58%. The losses due to CLS disease can be avoided by planting resistant cultivars. Crop debris and weed hosts should also be removed at the time of planting. When susceptible cultivars are planted, spray with fungicides such as chlorothalonil at 2 kg a.i./ha at 2-week intervals.

Mungbean yellow mosaic virus (MYMV) is sometimes occurred on mung bean in Ethiopia. Planting of MYMV-tolerant/resistant varieties is the best control measure

5.6 INSECT PEST MANAGEMENT

Beanfly: is the most important insect pest of mung bean. It causes significant damage during the seedling stage. The adult flies are too tiny and cannot be recognized easily. The bean fly maggots feed inside the plant stem and their damage cannot be seen from the outside. Mung beans must be protected against bean flies. At AVRDC (Asian Vegetable and Development Center), monocrotophos or omethoate or dimethoate is sprayed at 3, 7, 14, 21, 28, and 35 days after emergence. The first three sprays are very important and must not be delayed.

Aphids

Usually occur on mung bean. If you notice unusually high aphid populations (over 20 insects/plant), spray an insecticide such as dimethoate once a week until aphids are eradicated (AVRDC website). In Ethiopia, aphids occur when there is severe drought.

Mung bean is also infested by pod borers. When infestation of pod borers is very severe over large areas of your field, spray chlorpyrifos or fenvalerate at weekly intervals, until the infestation is controlled (AVRDC website).

Mung bean is sometimes attacked by stink bugs. If you observe unusually high populations of this pest (3-4 insects/meter rows) uniformly over an entire field when pods are still green, spray with fenvalerate or deltamethrin at weekly intervals until the infestation stops.

Bruchids

Commonly called pulse beetles or cowpea weevils, attack mung bean both in the field and storage. But the greater losses occur in stored grains. The nutritional quality of the grains deteriorates because of bruchid infestation rendering them unmarketable.

To control bruchids: clean storage area properly, dry seeds well, and apply non-toxic chemicals such as vegetable oils. For large-scale storage, fumigation with phosphine or other suitable fumigants can be adopted. Always follow the label directions whenever using any pesticides.

5.7 HARVESTING

Pod maturity in mung bean is not uniform because the plants flower over an extended period. This makes it difficult to decide when to harvest. Generally harvesting should begin when one half to two-thirds of the pods are mature. Seeds might be between 13%–15% moisture at this

time. Some growers leave the plants to allow further maturity of the pods and then combine using a pick up header on a small grain combine. This is an especially useful harvest system for the vine type varieties or when there is delayed maturity or problem of weeds present. Direct combining can be done in weed free, uniformly mature fields of the upright growth habit type of mung bean. In Africa, the mung beans are handpicked as the pods mature. As many as five pickings are done on some high yielding lines. After harvesting, the pods are dried under the sun. The well-dried pods are then threshed by various methods depending upon the quantity harvested. For a small amount of mung bean the grain is threshed out by beating the dried pods with a stick. For a large amount of mung bean, threshing is done by trampling of draft animals, or tractors, and by using locally made threshing machines. At present, the majority of mung bean grain is threshed by hand.

Drying and Storage

Prior to storing, remove all leaf material, stems, immature pods, dirt, insect parts and other debris. Mung beans at about 12% moisture can then be stored in regular grain bins previously fumigated to control bean weevils. If beans have higher than 12% moisture then they can be dried slightly by sun until they are near the 12% moisture content. Because they will be sprouted, care should be taken to keep all possible contaminants away from the storage area.

6 MIAZE

Maize variety is a group of plants that are distinct from other groups and its identifying characteristics are constant in time and space. There are two types of maize varieties: open pollinated varieties (OPVs) and hybrids, examples of OPVs are Melkasa-2, Gibe-1, Gambela comp-1 and Hora. Hybrid is produced from two or more genetically distinct parents. BH-540, BHQPY-545, BH-660, BH-670, BH-543, BH-140,
The main advantage of OPVs is that farmers can save their own seeds for planting the following season for at least three years.

6.1 RECOMMENDED AGRONOMIC PRACTICES

Improved varieties give high yield whenever they are planted under the recommended management practices in their areas of adaptation. The growers should strictly follow the recommended management practices to exploit the yield potential of the improved varieties.

Table-1. Released maize varieties with their agro-ecological adaptations and some agronomic characters

Crop	Variety	Year of release	Altitude (m)	Rain fall (mm)	Plant height (cm)	Ear Placement (cm)	Days to Maturity	Seed Colour	Yield (qt/h)		Disease Reaction			
									Researvh Station	Farmers field	MSV	GLS	TLB	CLR
Hybrids	BH-660	1993	1600-2200	1000-1500	255-290	145-165	160	White	90-120	60-80	_	T	T	R
	BH-540	1995	1000-2000	1000-1200	240-260	110-120	145	"	80-90	50-65	_	MT	MT	MT
	BH-140	1988	1000-1700	1000-1200	240-255	105-120	145	"	75-85	47-60	_	MT	MT	MT
	BH-543	2005	1000-2000	1000-1200	250-270	140-150	148	"	85-110	55-65	_	MT	MT	T
	BHQPY-545*	2008	1000-1800	1000-1200	250-260	120-140	144	Yellow	80-95	55-65	_	T	MT	MT
	BH-670	2001	1700-2400	1000-1500	260-295	150-165	165	White	90-120	60-80	_	T	T	R
	BHQP-542*	2001	1000-1800	1000-1200	220-250	100-120	145	White	80-90	50-60	_	T	MT	MS
	AMH-800	2005	1800-2500	1000-1200	205-225	105-125	175	"	70-80	55-65	_	T	T	T
	AMH-850	2007	1800-2600	1000-1200	220-235	120-130	183	"	80-120	60-80	_	T	T	T
OPVs	Hora	2005	1800-2400	1000-1200	200-215	100-120	170	"	60-70	40-45	_	T	T	T
	Kuleni	1995	1700-2200	1000-1200	240-265	130-145	150	"	60-70	40-45	_	T	T	R
	Gibe-1	2000	1000-1700	1000-1200	240-260	130-140	145	"	60-70	40-45	_	MT	MT	T
	Gutto	1988	1000-1700	800-1200	165-190	90-110	126	"	30-50	25-30	_	MT	MT	MT
	Morka (improved UCB)	2008	1600-1800	1200-2000	270-300	145-180	180	"	70-90	40-60	_	T	T	T
	Rare-1	1997	1600-2200	900-1200	250-270	130-150	163	"	60-70	40-45	_	T	T	T
	Melkasa-1	2000	Low moisture stress	600-1000	140-160	65-70	90	Yellow	35-45	25-35	_	_	T	T
	Melkasa-2	2004	Low moisture stress	600-1000	170-190	80-90	130	White	55-65	45-55	_	_	T	T
	Melkasa-3	2004	Low moisture stress	600-1000	170-175	75-80	125	"	50-60	45-50	_	_	T	T
	Melkasa-4	2006	Low moisture stress	600-1000	160-170	70-80	105	"	35-45	30-35	_	_	T	T
	Melkasa-5	2008	Low moisture stress	600-1000	180-190	80-90	125	"	40-50	35-40	_	_	T	T
	Melkasa-6Q*	2008	Low moisture stress	600-1000	165-175	70-75	120	"	45-55	30-40	_	_	T	T
	Melkasa-7	2008	Low moisture stress	600-1000	170-182	80-90	115	Yellow	45-55	30-40	_	_	T	T
	Abo-Bako	1986	300-1000	900-1200	220-230	120-130	112	White	50-60	35-45	T	T	T	T
	Gambela Comp-1	2001	300-1000	900-1200	200-220	105-115	116	"	60-70	40-50	R	T	T	T

T=tolerant, R=resistant, MT=moderately tolerant, MS= moderately susceptible,
MSV= maize streak virus, GLS=gray leaf spot, TLB=turcicum leaf blight, CLR=common leaf rust
"-" = disease not important (MSV is important mainly around Gambebela, while GLS is important mainly in high rain fall areas)

6.1.1 Land preparation and planting

Site selection and land preparation: Maize plant is sensitive to waterlogging. Waterlogging more than 24 hours at early stage can kill the crop. Maize grows best in deep and loamy soils with a pH range of 5.5 – 7.8. In general, maize can tolerate from 5 to 45oC. Frost areas should be avoided during site selection.
Regarding land preparation, plowing 2–3 times depending on the field situation is recommended. Conservation tillage is also the other option with the application of herbicides.

Planting time: Planting dates should be based on the onset of the rainfall of the growing season in each agro-ecology. It is advisable to plant early whenever there is enough moisture in the soil to benefit from higher soil fertility present at the beginning of the rainy season and to achieve physiological maturity before the end of the rainy season.

Planting depth: If the seed is planted too deep, the seedling depletes food reserves before it emerges out of the soil surface. On the other hand, leaving seeds on the surface or too shallow planting expose the seed to wild animal damage and desiccation. Therefore, the optimum depth of planting is 5 – 7 cm.

Plant density: Row planting is recommended for maize production. The optimum plant density differs for different varieties depending on plant height, and maturity.

The spacing for medium/early maturing varieties of low moisture stress areas (Melkasa-2, 3, 4, 5, 6Q & 7) and all highland varieties should be 75 cm x 25 cm (53,333 plants/ha). For extra early maturing variety (Melkasa-1) spacing of 75 cm x 20 cm (66,666 plants/ha) is recommended.
Seed rate of 25 kg/ha is recommended, but this may vary depending on seed size and planting density.

6.1.2 Fertilizer type, rate, method and time of application:

Maize plant uses different nutrients from the soil. Nitrogen, phosphorus and potassium are required in large quantities.
Currently, only nitrogen and phosphorus are applied through chemical fertilizers in Ethiopia.
Fertilizer recommendations are location specific and recommendations for some areas like Melkasa and Gambella are DAP (NPS) 100kg/ha and Urea 50kg/ha. Application of the whole rate of DAP/NPS at planting and split application of urea is recommended. For the low moisture stress area the whole dose of urea is applied at knee height. Band/side dressing/spot application of fertilizers is advisable for efficient use of the fertilizers.

In addition, well-decomposed manure and compost could be used as source of nutrients. Five t/ha compost plus 50 kg/ha of NPS (applied at planting) and 35 kg/ha urea (top dressed at knee height/Shilshalo) is recommended. Generally, the recommended rate of farm yard manure is 16 t/ha.

6.1.3 Weed control

Weeds damage maize crop mainly by competing for nutrients, light and water. Maize is very sensitive to weed competition from emergence to flowering stage. Therefore, maize fields should be kept weed free. However, for practical and economic reasons, twice hand weeding (the first one at 25 to 30 days after sowing and the second at knee height) is recommended. Slashing at flowering stage is also recommended.

In addition, pre-emergence herbicides, primagram or gesaprim, at the rate of 4 – 5 lt/ha supplemented by hand weeding is recommended. Use of lasso-atrazine is also recommended at the rate of 4-5 lt/ha after planting but before emergence of the crop. Rotation or intercropping of soybean with maize is recommended to reduce striga infestation .

6.1.4 Cropping systems

.**Crop rotation:** Maize crop benefits when rotated with legumes as legumes can fix nitrogen. Soybean, haricot bean and other pulse crops are recommended for rotation with maize. In addition, niger seed followed by haricot bean as precursor crop for maize is recommended
.
Intercropping: is the practice of growing two or more crops simultaneously on the same field. Intercropping 75% plant density of haricot bean into 100% plant density of maize during oxen-cultivation (shilshalo) at about 35 days after planting is recommended.

Relay cropping: is a practice in which a second crop is planted in maize field after maize crop has reached its reproductive stage of growth but before it is ready for harvest. Relay planting of sweet potato at 50% flowering of maize is recommended. In addition, relay planting of haricot bean starting from 50% flowering to 15 days after flowering of maize is also recommended.

6.1.5 Water requirements

Maize is an efficient user of water in terms of total dry matter production and it is potentially the highest yielding grain crop of all cereals group. For maximum production a medium maturing varieties grown for grain requires between 500 – 800 mm of water depending on specific climatic conditions of the area. The crop is fairly tolerant to mild water stress during its vegetative period and also during the ripening of the grain. However, it is both very sensitive to water deficit and excess watering during flowering. i.e tasseling and silking . The crop factor (kc) relating water requirements (ET) to reference evapo-transpiration (ET) for different crop growth stages of grain maize is for the initial stage 0.3-0.5 (15 to 30 days), the development stage 0.7-0.85 (30 to 45 days), the mid-season stage 1.05-1.2 (30 to 45 days), during the late season stage 0.8-0.9 (10 to 30 days), and at harvest 0.55 0.6, But this should be determined locally.

Irrigation scheduling

In the case of maize, where water supply is limited it is advantageous to meet as far as possible, full water requirements so as to achieve maximum yield from limited area rather than to spread the limited water supply over large area. Soil water depletion up to about 55 % of available soil water has a small effect on yield. Indeed, it is beneficial to allow somewhat greater depletions during the early stages of growth in order to enhance deep rooting. However, depletion of 80 % or more is allowable during the ripening period. If there is adequate supply of irrigation water, intervals of 14-21 days will be sufficient to ensure good yields. The depth of water that could be applied per irrigation is about 5 cm. When severe water deficit is unavoidable, then it is recommended to save water during vegetative and yield formation periods and be supplied for the crop during flowering period without incurring additional yield loss.

Methods of irrigation

The appropriate and recommended method of irrigation for maize, where substantial water resources and lab our forces are available, is the furrow irrigation method. Maize is irrigated by furrow method usually using a spacing of 0.6-0.8 m. However, in undulated topography and lab our shortage, sprinkler irrigation will be the more appropriate one.

6.2 RECOMMENDED MAJOR MAIZE INSECT PESTS AND DISEASES MANAGEMENT PRACTICES

Many insect pests and diseases have been recorded attacking maize in the field and in the store in, but only a few are economically important. The major insect pests are maize stem borers, termites, maize weevil and grain moth. Gray leaf spot (GLS), turcicum leaf blight (TLB), common leaf rust (CLR) and maize streak virus (MSV) are the major diseases.

6.2.1 Field insect pests and control methods

Maize stem borer (*Busseola fusca)*
Cultural control: Removal of volunteer plants and alternate hosts (elephant grass, wild sorghum, sorghum tillers grown from ratoon etc) is recommended. After harvest, horizontal placement of infested maize stalks in the sun for 4 weeks is also recommended. Besides, the infested maize stalks should be cut at soil level, so that most larvae could be removed from the field. In general, early sowing as soon as the rain starts can offset the damage caused by stem borer Maize/legume intercropping is also effective in controlling stem borer.

Botanical control: Eendod (*phytolacca dodecandra L*.) at 2, 10 and 20 kg/ha for fresh leaves; 1, 2 and 10 kg/ha for dried leaves;; and pepper tree (*Schinus molle L*.) 10, 20 and 30 kg/ha for fresh fruits, and 2, 10 and 20 kg/ha for dried fruits, are recommended. Neem seed and pyrethrum flowers at 8% concentration are also recommended. For efficient control more than 2 applications are needed.

Chemical control: Diazinon 60% (1-2 l/ha), Ethiosulfan 35% (2-2.5 l/ha), carbaryle 1.28 kg/ha a.i, cypermetrin (16 ml a.i/ha) and carbofuran 1.5 kg a.i/ha are recommended.

Termites
Cultural control: Mulching (maize stover and other grasses), intercropping maize with soybean at the ratio of 2:1, crop rotation (maize with legume), spread of wood ash around the base of the crop and queen removal are recommended. In addition, use of lodging resistant and early maturing maize varieties are advisable.

Botanical control: Application of neem seed powder at 45 kg/ha is recommended.

Chemical control: Diazinon, 60% EC at 2.5 l/ha, GUFOS at 200 ml/ha (for spray) and fipronil at 10-11.7 ml/kg (for seed dressing) are recommended.

6.2.2 Storage insect pests (maize weevil and grain moth) and control methods

Adoption of the following integrated pest management package is recommended to ensure better storage of maize grain and seeds with minimized quantitative and qualitative losses:

- Harvesting at proper stage (timely harvesting),
- **Ear inspection/sorting**: Before shelling, ears should be inspected for pre-germinated ears, mouldy/diseased ears, insect damaged ears, etc. and removed.
- **Shelling**: Shelling at proper moisture content (13-14%), cleaning and disinfecting the sheller before use, maintenance of full-feed to sheller to avoid grain crashing by the

shelling machine, and checking for mechanical damage of the grain and taking correction measures are recommended during shelling.

Grain treatment and storage management:

- Proper and careful drying of grains to safe moisture level after shelling (12.5%)
- Maintenance of sanitation and hygiene of store as well as grains 4 to 6 weeks prior to placing new harvest for storage.
- Use of both preventive and protective chemicals (Actellic 2% D and Malathion 5% D at 50 g/qt)
- Fumigation of granaries and warehouses with chemicals such as phostoxin, quickphox and others.
- Use of plant products and inert materials (Chenopodium plant powder at 1.25% w/w, neem seed powder at 2% w/w, vegetable oils at 5 ml/kg, triplex at 0.1% w/w, wood ash at 2.5% w/w)
- Use of improved storage structures (sealed and elevated with rodent baffles)
- Use of air tight storage (modern hermetic cocoon

6.2.3 Major diseases and control methods

Grey leaf spot (GLS*) (**Cercospora zeae-maydis****)***

Cultural control: avoid infected plant debris, recommended spacing between and within rows, deep ploughing to bury crop debris, crop rotation and early sowing (at the onset of rainy season) are recommended.
Resistant/tolerant varieties: Use varieties with relatively better resistance/tolerance to the disease. Example: BH-670, BH-660, Kuleni, and others.

Chemical control: spraying of benomyl at the rate of 0.5 kg/ha is recommended.

Turcicum leaf blight (TLB) (Exserohilum turcicum)

Cultural control: use of adequate inorganic fertilizer in combination with farm yard manure, intercropping with legumes and crop rotation, use of optimum seeding rate, spacing and early planting of maize are recommended.
Resistant/tolerant varieties: using varieties relatively resistant/tolerant to the disease.
Examples: BH-670, BH-660, Kuleni and others.
Chemical control: use of combination of mancozeb and propoconazole at the rate of 2 kg active ingredient per ha of maize (2-3 times of application at ten days interval) is recommended.

Common leaf rust *(CLR*) (*Puccinia sorghi*)

Cultural control: Timely planting, intercropping maize with legume and crop rotation reduces the level of infestation.

Resistant/tolerant varieties: using varieties relatively resistant/tolerant to the disease. Example BH-670, BH-660, Kuleni and others

Chemicals control: combination of mancozeb and propoconazole at the rate of 2 kg active ingredient per ha of maize (2-3 times of application at ten days interval) are recommended.

Maize streak Virus (MSV)

Cultural method: early sowing, inspection and rouging infected plants especially at early stage are recommended.
Resistant varieties: Use varieties like Abo-Bako and Gambella comp-1 **Chemical control:** Controlling the vector (*Cicadulina mbila)* that transmits the disease using insecticide is recommended.

Ear and kernel rot disease (*Diplodia zea, Fusarium monoliforme and Gibberela zea*)
Chemical control: seed dressing with fungicide Luxan TMTD at 200-500 g/qt of seed is recommended.

7 BANANA

7.1 LAND PREPARATION

Soil should be deeply ploughed in both directions and harrowed to a fine enough tilth to enable irrigation furrows to be laid out effectively along each plant row. The land for banana plantation should be well prepared and leveled. After leveling the field, it is important to make a furrow of 30 m length and with 2 m apart one from another. Depending on the soil type of the field the furrow length could be shortened or lengthened. As a general rule, in sand soils short furrows are recommended, while in heavy soils the furrow length could be longer. As part of land preparation one or two months prior to planting, it is important to make a planting hole at the places where the pieces of planting materials of banana would be planted later. Make the planting holes 60 cm deep, 60 cm wide and 60 cm long. It is important that the soil from the top should be put on one side and the soil from the bottom on the other side. Then fill the holes with compost and manure to enrich the soil within the planting hole with nutrients that could be used further by the new planted banana suckers.

7.2 PREPARATION OF SUCKERS FOR TRANSPLANTING

Usually, banana is propagated vegetatively, using suckers and piece of corm with one to three eyes. Both types being dug out from around mature plants. In Ethiopia, suckers are normally used. It is important to select the right type of suckers as this will affect subsequent growth and yield. Suckers of different ages are used as planting materials. The following points should be considered during sucker preparation: (1) Use suckers taken from banana plants that are between 3 and 6 years old; (2) After a seed-piece is dug up, all soil, roots and trash should be completely removed; (3) Suckers should be between 50 cm and 1 m high and broad at the base and let them dry in the shade for 3 or 4 days before planting; (4) If nematode lesions are detected on the roots, these should be pared off along with any dark and reddish tissue, until the seed piece is clean and white leaving a few buds; (5) Just before planting them, trim them at a point 50 cm from the base of the plant and dip them in boiling water at 52 0c for about 20 minutes in which potassium permanganate is mixed or dipping the planting material in a nematocide may reduce damage from nematodes and boring insects; (6) It is important to select uniform size of suckers; (7) Rhizomes, or “sword suckers” 50 to 60 cm tall and enlarged at the base, which bear only long slim narrow leaves are most productive suckers and more preferred for propagation; (8) “water suckers” with a size of 1 to 1.5 m long with broad leaves can be used for planting without topping but these are not preferred as such, due to smaller corms; (9) “Maiden head sucker”, which is from 1 to 1.25 m tall and from a plant, which has not yet flowered can be used as planting material, if there is a shortage of planting material ; (10) If seedlings of improved varieties of banana are not available, it is recommended to choose and prepare planting materials from the local cultivars and (11) After five years on average the banana becomes old and reduced its productivity, and therefore, recommended to replace the plantation with new ones. 208

7.3 PLANTING AND PLANTING METHODS

Holes of 50 cm deep and 50 cm wide in diameter are prepared at least two months ago before planting. The top soil should be put separately and mixed with about two buckets of well rotted manure if available. The planting distance between hills depends primarily on the size or the height of the variety being cultivated, the type of soil, the amount of fertilizers applied, and the pruning practices existing in the area. The variety Dwarf cavendish can be planted in rows at a distance of 1 m between plants and 2 m between rows, while the variety Giant cavendish can be planted in 2.5 x 2.5 square meters. The deeper the soil, the closer can be the planting distance for a variety, as long as excessive shading does not occur. However, for irrigation convenience a spacing of 2.5 m between rows and 2 m between plants with a total plant population of 2, 000 plants/ha is sometimes recommended. At planting time, put the soil from the top into the bottom of the hole and place the sucker in the earth. The base of the sucker is now 10 centimetres from the surface of the ground. Put compost round the young plant. Put the bottom soil on the ground surface. Place about 40- 50 grams of N and 20-25 grams of P fertilizer per hole 10 cm deep before planting mixing with 5 kg of manure, plus 25 grams of a granular nematocide in the bottom of the hole and return back to the hole a 10 cm thick layer of soil. If it is not possible to add a granular nematocide, it is good to dip suckers in a solution of copper sulphate, or temik or some other chemicals used for this purpose. The soil around the seed piece should be well compressed and irrigated soon after. The best time for planting rainfed bananas is at the beginning of the rains, although with a continuous supply of irrigation water any time of the year would be satisfactory for transplanting seed pieces to their permanent place.

7.4 WEED CONTROL

Weed control is necessary at early stages of growth before a plantation is established, whereas an old plantation usually shades out the weed. weed control is also required on the borders of plantations, around the irrigation canals and drainage ditches, and pathways between plantations. Application of recommended herbicides is the most efficient method of controlling weeds by taking care not to damage the leaves of banana. If the land is well prepared, maintained appropriate spacing, and mulched, weed control should require less effort. Cultivation should always be shallow in order to avoid or minimize damage to the roots. In order to minimize weed competition it is also recommended to inter crop some leguminous crops between the banana rows.

7.5 FERTILIZER APPLICATION

Banana is a heavy feeder and yields can be increased dramatically by applying fertilizers. Bananas need fertile conditions and abundance of soil moisture for best growth and optimum production. The type of development the plant makes in the first 3 to 4 months determine the weight of the bunch and number of hands the plant can bear. The N-P-K formulation to be used depends on the type of soil. The main nutrient requirement is nitrogen, which is generally applied in the form of urea. N stimulates faster growth, greater leaf area development, and increased fruit size. P needs is relatively low as compared with that of N and K. For a year old

banana plant, it is recommended to apply 50 g of N at the time of planting and 50 g of N after 4 months of planting /in both application use 100 kg/ha rate/. Nitrogen should be applied in small amounts at frequent intervals throughout the year. The appropriate recommendation for phosphorus fertilizer is 50 kg/ha of P2O5 or about 50-100 grams P2O5 per plant after 8 months of planting. Apply the recommended fertilizer 10 to 15 cm far away of the stem of the plant.

The recommended P can be applied in one application in the planting hole and thereafter once or twice yearly as surface dressings. P deficiency causes a premature drying of the lower leaves. Potassium greatly increases yields and pseudostem growth, improves fruit quality and storage life, and promotes disease resistance. Deficiencies of potassium indicate yellowing around the outer edges of the leaves; more severe hunger causes the leaf tips to turn reddish-brown and die. K hunger is also associated with the disorder called “premature yellowing” of the leaves. For well developed banana plant apply 100 kg/ha rate of N every four months and 50 kg/ha of P2O5 once in a year. Apply 8- 10 kg per plant of well-decomposed manure, whenever available.

The amount of fertilizer used depends on the number of mats per hectare; about 600 kilograms of nitrogen per hectare per year is an appropriate estimate for a deep alluvial soil. If there are 1,000 mats per hectare, then each mat receives 600 grams of nitrogen per year. Fertilizer should be applied in a circular band around the mat. After planting a seed-piece and up to three months after emergence, the band should have a radius of 50 cm. The radius should be enlarged as the plant matures. The radius of the fertilizer placement around mature mats should be between 1- 1.5 m. On the average, a plantation should be fertilized about every sixth week. During the rainy season, this interval could be reduced to five or even four weeks, and during the dry season under rainfed cultivation it might be increased to seven or eight weeks.

The addition of manure in the planting holes and as a side dressing is beneficial nutritionally and also contributes to improving the water-holding capacity of the soil. The practice of chopping banana residues into small pieces and spreading them in a thin layer around the plants is also beneficial, since this organic material is high in potassium as well as acting as mulch, which conserves soil moisture. Application of 3- 5 kg/plant of farmyard manure is recommended to be applied under banana and worked out with the soil.

7.6 WATER REQUIREMENTS

Being a long duration crop, the total water requirements of banana are high water requirements per year vary between 1, 200 mm in the humid tropics to 2, 200 mm in the dry tropics. For rainfed production average rainfall of 2, 000 to 2, 500 mm per year, well distributed is desirable, but banana grows under less rainfall condition. As it is indicated above, banana requires an ample and frequent supply of water. Water deficits adversely affect crop growth and yield of banana.

The establishment and the early phase of the vegetative periods determine the potential for growth and fruiting and adequate water and sufficient supply of nutrients is essential during this period.

- Water deficits in the vegetative period affect the rate of leaf development, which in turn can influence the number of flowers and consequently it can influence the number of hands and bunch production.
- Water deficit during the flowering period can also limit the leaf growth and number of fruits.
- Water deficit during the yield formation period affect both the fruit size and quality and consequently premature ripening of fruits can happen.

The banana plant has a sparse shallow root system. Most feeding roots are spread laterally near the surface. Rooting depth not exceeding generally 0.75 m. in general, most of the water is extracted from the first 0.5- 0.8 m soil depth, of which 60 % is from 0.3 m.

7.6.1 Irrigation scheduling

A depletion of total available soil water is not more than 35 % during the total growing period is harmful to growth and fruit production. Therefore, frequent irrigation is important. The irrigation interval will depend on the total crop water requirement /ETm/ and the soil water-holding capacity in the rooting depth and may vary from 3 days under high evaporative conditions and light soils up to 15 days under low evaporative conditions and high water retaining soils. Under limited irrigation water supply it is advantageous to reduce the depth of each water application rather than to extend the irrigation interval.

7.6.2 Irrigation methods

In Ethiopian condition, the appropriate irrigation methods for banana production are furrow and basin irrigation methods. However, sprinkler irrigation systems with small application at frequent intervals are commonly being used in commercial plantations and drip irrigation, particularly in areas with scarcity of water are also practicable.

7.7 PRUNING

Banana is a perennial plant, but each sucker or pseudostem, which arises from the mother plant, bears only one bunch of fruits. The removal of suckers is an important operation, which is often neglected. Pruning is the process of cutting suckers, or followers, at ground level, where they emerge from the mother plant. The pruner allows 40 to 42 suckers of the same age to develop in scattered locations in a hectare. Pruning is done usually at 10 to 14 days intervals.
Every time 3 suckers including the fruiting sucker are allowed to maintain. In addition, it is very important to avoid old dried leaves in order to minimize disease incidence and damage and to allow sufficient sunshine penetration. Furthermore, during flowering it will be vital to reduce the leaves, by leaving 6 to 8 leaves in order to increase the fruit weight.

Crop Pest Control

Disease control In the tropics, bacterial wilt and Bunchy Top virus are the most important diseases that may cause extensive damage. A number of fruit- blemishing diseases can also cause reduction in fruit quality. Insect pest control: Bananas are attacked by a wide range of insect pests which include banana root borers, red rust thrips, weevil, scales, bag worms, chalcid wasps, peel-feeding caterpillars and many other insects as well as nematodes.

Banana weevil

Banana weevil /cosmopolites sordidus/ is one of the most serious insect pests that attack banana. The larvae feed, tunnel and develop in the plant corm. This weakens the plant and predisposes it to wind damage. This insect makes holes in the base of the banana plant and lays its eggs in these holes. The eggs turn into little weevils. They eat out the heart of the banana plant. You do not see the weevils, but if the fruit bunch does not develop, or if the bunch is small and badly shaped, there may be weevils inside. To find out if there are weevils in the plantation, cut pieces of the plant's apparent trunk lengthwise. Put two pieces on the ground near each plant facing downward. look every day at these pieces. If there are weevils in the plantation, they will hide under the pieces of "trunk" and adult weevils can then be collected every 48 hours.

Control methods: Before planting, dip the suckers in lukewarm water, or in water mixed with Némagon, if there are eelworms in the plantation, put Némagon in the soil and for the control of banana weevils, it is recommended to use 25 to 30 g of BHc.

Other pests

There are other pests that attack bananas such as thrips, aphids, scale insects, etc. These insect pests are controlled using BHc, Aldrin or Dieldrin. In addition to insect pests banana is attacked by nematodes of which the burrowing nematode /Radopholussimilis/ is a dangerous endoparasitic, which destroys feeder roots and reduce yield significantly. Root knot nematode also attacks banana. Controlling is possible by rotation at least two- three years, pre- planting fumigation and by treatment of propagating material by placing the bases in hot water for 10- 20 minutes, or dipping with non- phytotoxic nematocides.

7.8 HARVESTING

Banana varieties vary greatly in their rate of growth. Generally, the diploid varieties grow much faster than triploid varieties. A banana will flower and produce fruit within 6- 18 months after planting. The fruiting stalk is harvested when the fruits are still green but after the ridges have begun to become rounded and the top most hands have become light green. The quality of fruit allowed on the plant is usually lower than that ripened off the plant, due to fruit splitting and lower sugar content.

The duration between the emergence of a bunch (shooting) and its harvest is an important factor in the marketability of the product. This duration depends on the variety and seasonal

temperatures. After the bunch emerges, folds down, and all hands are exposed, it requires 60 to 70 days before the fruit is ready for harvest. Bananas must not ripen on the plant. For local markets, the bunch should be harvested as soon as the fruits are full or round. For more distant markets, they should be harvested earlier when more angular. The bunch of fruits finishes ripening tied to a rope, in the shade. If the bunch ripens on the plant, the bananas split and become mealy. Bunches can be kept longer, if they are harvested unripe. Bunches are cut and sold whole, or the hands are separated, graded and packed before sale. Since banana is highly perishable fruit great care must be taken to prevent bruising during the picking and transportation operations. It is a common practice to transport banana while they are still attached to the stalk; however, as mentioned earlier, cavendish types are often severely bruised by this treatment.

Yield

A well- cared- for plantation has a big output. The third harvest on any one plantation is the biggest, of all. From the fourth harvest, the output begins to decline and after five years a plantation is recommended to be changed with the new one. The yield of a plantation may vary between 30 and 50 tons per hectare. In African condition, on average 23 to 34 tones/ha is a common output

8 PAPAYA (CARICA PAPAYA)

The fruit is a berry with a green rind which changes to yellow in most cultivars when ripe.
The inside flesh is yellow or occasionally orange, and seeds are black located in a central cavity in the fruit and surrounded by a gelatinous material. The fruit has an high content of beta-carotene (vitamin A) and vitamin C.

8.1 IMPORTANCE AND DISTRIBUTION

Papayas are locally important throughout the tropics where they thrive in frost-free areas below 1500m in elevation. Little fresh fruit is exported since it is highly perishable and requires careful handling to reach distant markets in a saleable condition.

8.2 ENVIRONMENT AND SOILS

The papaya succeeds on a wide range of soil types providing that drainage is good. A windbreak is advisable if the area is subject to high winds since the plants are susceptible to breakage. Papayas are tolerant of drought once established but in areas with a pronounced dry season little fruit will be set except during the wet season. Irrigation will increase yields in low rainfall areas but has a disadvantage in that, if irrigation is excessive, the flavour of the fruits may be poor. Flood and furrow irrigation are the most common methods used.

8.3 PROPAGATION

Propagation by seed is the most practical method. Seeds can germinate in 2-3 weeks and can be sown in flats of soil or in seedbeds. The seeds germinate equally well if extracted both from a stored or fresh fruit. The plant selected should be a superior cultivar hermaphrodite. They are transplanting when the seedlings are 10 cm tall.

A method of starting the seedlings without disturbing the roots is to plant 4-8 seeds in a container and then thin to two to four of the strongest when they are about 10cm tall. Then at this stage they can be transplanted in the field without disturbing the roots. Young papaya seedlings are very susceptible to damping-off organisms so the soil in which seeds are sown should be sterilised. Papaya Transplanting in the field as soon as papaya has reached the proper size the seedlings should be transplanted with four seedlings in each planting station 3mx3m. The plants are then thinned to one after flowering and the sex has been detected.

Papaya are primarily dioecious although hermaphrodite forms which bear perfect flowers are common in some cultivars (Solo).Generally one male tree every twelve (12) female is recommended for dioecious plants (with male and female flowers on different plants).
For hermaphrodites cultivars male trees are not necessary and can be discarded. Within this type of plants the “Solo” cultivar , which is the most important and stable hermaphrodite commercial cultivar, seeds should be obtained only from hermaphrodite plants which have been self-pollinated or cross pollinated with another hermaphrodite.

Male trees can be recognized bearing a long pendulous inflorescence on which small fruit occasionally can be formed. Female plants have sessile and larger flowers on the trunk. The

flower has large functional pistil (female part of a flower, see drawing) without stamens (male part of a flower,

8.4 FERTILIZERS

Papayas are very responsive to fertilizer and yields can be significantly improved by proper fertilization. Since the fruit is formed in the axles of the leaves, plants must be kept growing continually for maximum yield. About 0.9-1.4 kg of Urea and DAP fertilizer or equivalent per year per tree divided into three applications is recommended.

8.5 PESTS AND DISEASES

Few insect pests seriously damage papayas but damage by diseases can be severe and often accounts for the short life of the tree. Seedlings are very susceptible to damping off and older plants are susceptible to root and collar rots. All of these diseases are most serious in waterlogged soils, therefore the importance of good drainage cannot be under-estimated. Perhaps the most potentially serious disease is bunchy top caused by a virus transmitted by homopterous insects.

Control
Bunchy top-infected plants yield little or no fruit and should be removed to prevent spread of the virus to healthy plants.
Root-knot nematodes can also be a serious problem, especially in sandy soils. If moisture and fertility levels are high, plants will produce fairly well despite nematode infection. However, under dry, hot conditions severe yield reductions can be expected.

Control
The application of mulch around the base of the tree is often beneficial in reducing nematode populations.
Anthracnose (Colletotrichum gloeosporioides) causes spotting of the fruits which renders them unusable. Powdery mildew on the leaves may also be a problem.

Control
Fixed copper or benomyl sprays will control both of these diseases.

8.6 HARVESTING AND HANDLING

Fruit is harvested at the first signs of yellowing if it is to be sent to distant markets; it may remain on the tree a day or two longer if intended for local markets. Papayas should be stored at temperatures between 10^{o}C and 13^{o}C for maximum storage life. Lower temperatures will cause chilling injury and fruits will fail to ripen properly. Since the skin is extremely delicate, very careful handling is necessary. A post-harvest thiobendazole dip will aid in anthracnose control (damage of fruit).

Maradol Variety is recommended for Ethiopia
The plant has a dwarf habit, generally it does not grow taller than 2 meters, it bear big oval fruits of 1Kg to 1.5 Kg. It generally produces 66% of hermaphrodite plants, 33 % of females and 1 % of the other forms 1%. The fruits which ripen in about 9-10 months from planting have a sweet flavor with flesh of orange to red colour, rich in vitamin A and vitamin C

9 MANGO

Mango in the tropics grows almost everywhere but for good commercial fruit production, a prominent dry season lasting more than three months is necessary. Mangoes prefer climates with much sunshine and a little rain. However, flowering is rather erratic in the tropics due to variable temperature and rain falling at the wrong time and high humidity.

9.1 CLIMATE REQUIREMENTS

Mangoes grow best in seasonally wet/dry climate zones of the lowland tropics. A dry and/or cool season causes uniform floral initiation and tends to synchronize bloom and harvest. Mango is best adapted to hot, dry areas that receive less than 400 mm of rainfall annually, but supplemental irrigation is desirable for highest yields in those areas.. Mango trees should be protected from strong winds, but windbreaks that shade or compete with them should be avoided.

Temperature

Mango does not attain a truly dormant state, but ceases growth at temperatures below 13 – 15 ºC. Temperatures below 15 or above 37 °C at flowering can cause flower abortion, loss of pollen viability, and occasionally seedless fruit development (small).

For optimum growth and productivity, 20–26°C is believed to be ideal. Temperatures exceeding 40°C may, especially in hot/dry areas, lead to sunburn of fruits and stunting of tree growth. The amount of rainfall in a given locality is not as important as its intensity and distribution. Rainfall of 500–1000 mm at the right time of the year is sufficient for successful cultivation.

Soils Suitability

Mangoes are adapted to many soil types, it will grow in almost any well-drained soil whether sandy, loam or clay, but avoid heavy, wet soils. A pH between 5.5 and 7.5 is preferred. They are somewhat tolerant of alkalinity. Moderately sloping sites are also recommended to prevent water logging. Deep soils without impermeable layers permit the development of deep taproots that aids in drought tolerance and wind resistance.

9.2 PLANTING AND PLANTING MATERIALS

9.2.1 Propagation:

Mangos are propagated either vegetatively or by seed. Seedlings are grown sometimes to produce new cultivars but mainly for use as.

The selection of suitable rootstock is as important as the selection of the scion.. It has a strong influence on the growth, yield, fruit maturity stage of final fruit development (ripeness) and soil adaptability, among other things. Seeds must be taken from ripe fruits and should be as fresh as possible at the time of planting. Before planting, the hard woody endocarp should be removed to examine the seed for disease or any damage caused by the mango weevil (*Sternochetus* sp.). Freshly sown seeds should be protected from high temperatures and dessication by providing shade. The seeds normally germinate in two to four weeks, and do best with bottom heat. Once seedlings emerge the shade is removed to harden the plants and produce sturdy stems. The seedlings are carefully lifted and all the malformed

and unhealthy ones are culled. The good quality seedlings are transplanted into polythene bags or containers not smaller than 18 x 35 cm they remain there until they are of pencil thickness with 3-5 red leaves at about 20 cm above soil level. This may be about one month after transplanting planting.

Besides, there are many other techniques used to graft mango seedlings, but the most common methods are side-graft, side veneer and wedge- and whip-graft.

Graft in the second year, using cleft, side or tongue (splice) graft in midsummer. Scion and stock should be swelling for a new flush of growth. Grafts are most successful if the leaves are allowed to remain below the graft, but remove suckers. Use pencil-sized scions of hard wood with three or four nodes. Cover with loose punctured white paper bag for shade.

A mango tree must never be transplanted while it is flushing or when the leaves are still tender; the best time to transplant is after the second flush has hardened. Seedling mangos will bloom and bear in three to six years after field planting.

9.2.2 Establishment

Mango is successfully grown on a wide range of soils. The essential prerequisites for good development of the trees are deep soils (at least 3 m), appropriate rainfall (500–1000 mm), good drainage, suitable altitude (0–1200 m) and preferably a pH value between 5.5 and 7.5.

The tree itself is not difficult to grow and, once well established, is relatively tolerant of drought, occasional flooding and poor soil condition. Irrigation in the first years after planting promotes flushing (and suppresses flowering), so that tree size increases quickly. Irrigation also widens the scope for intercropping the growing of two crops simultaneously in the same field, for example, with papaya, banana, pineapple or vegetables, during the establishment phase. When the trees are big enough to produce a substantial crop, irrigation is stopped, or at least interrupted long enough to impose quiescence leading to flower initiation.

Since mango is a long-lived perennial, the planting distance usually depends to a large extent on the vigor of the cultivar variety, type/rootstock plants propagated for further grafting/budding and on the environment. Overcrowding results in the production of fewer fruits that are poorly colored and sometimes infected with diseases.

9.2.3 Interculture

The removal of weeds not only avoids the competition for essential nutrients but also creates better physical soil environment for plant growth, particularly root development. It also helps in water movement in soil and in controlling some of the insect pests. Moreover, it ensures proper incorporation of the applied plant nutrients in soil and reduces their loss.

9.3 PLANTING DESIGN, TRAINING AND PRUNING:

Prior to planting, field should be deeply ploughed, harrowed and leveled. Pits of proper size should be dug at appropriate distances and filled by adding sufficient quantity of farmyard manure. The seedlings to be planted should be procured from reliable nurseries few days before actual transplanting.

Time of planting: The best time for planting is when there is sufficient moisture in the atmosphere. In the area of heavy rainfall, the best time of planting mango is the end of the rainy season. In tracts where the rainfall is less, the planting can be done in the early part of the monsoon for better establishment. The planting should be done in the evening; otherwise if the day turns out to be unusually hot or dry, the plants may wither due to excessive loss of water. If the sky is overcast, planting can be done during daytime also

Planting distance: The planting distance varies according to variety, the fertility level of the soil and general growth conditions in the area. Where the growth is excessive, the distance should be 14 x 14 m, but in the dry zones where the growth is less, it can be regulated to about 10 x 10 m. For high density planting, the distance can be 5 x 3 or 5 x 2.5 or 3 x 2.5 or 2.5 x 2.5 m.
For increased early production, an extra tree may be planted in between mango placement and the center of a 200-square meter to be removed later when overcrowding is prevalent.

Size of pits: In locations where the soil is loamy and deep, pits of 0.5 x 0.5 x 0.5 m be dug at desired distances. However, in shallow and hill soils, the pits should at last be of 1 x 1 x 1 m size.

Filling of pits: The pits should be filled with the original soil mixed with 10-50 kg well rotten farmyard manure. In the top two-third portion, the proportion of the manure and soil may be kept as 1:3. In case of stony soils, it is better to remove all the stones from the excavated material and remaining soils should be mixed with soil scrapped from the left over area. The pits should invariably be filled before the rainy season, so that there is maximum settling down before the advent of heavy rainfall and much before planting.

Planting of mango seedling: The plant with its ball of earth intact should be taken out of the soil or pot. The plant can then be placed with the help of a planting board in the centre of the pit by excavating as much soil as necessary to accommodate the root-ball. The moist soil of the pit is then pressed all around the root ball to complete the planting process. A small basin is then made and the plant is properly watered. The planting is always better to adjust it at the same height/depth at which it was in the seedling bag or the nursery bed.

Young Tree Establishment: Newly planted trees should be watered two or three times the first week, then once or twice per week for several weeks. Simply fill the water basin and let the water soak in. The water ring will gradually erode away over four to six months, at which time the tree can be considered established.

All lawn grass and weeds should be eliminated for several feet around the young mango, as the tree cannot compete for water and nutrients until it is much larger. As the tree grows, widen the grass-free area beyond the canopy. Organic mulches are excellent for mango trees. No pruning or training should be necessary except to remove deadwood.

Mature Tree Care. Cultural practices are designed to maintain good growth and production. Irrigation, nutrition, and weed and grass control are the major practices in mature mango tree care.

Irrigation is the same as for other established fruit trees–water slowly, deeply and thoroughly. Repeat as needed, based on soil type and prevailing weather. Weekly soakings during the summer are more than adequate.

Weed and grass control under the tree is desirable to reduce competition and can be easily maintained by use of organic mulch replenished as necessary.

Training: Normally, mango trees require very little training. However, the training of the plants during the initial stages is very essential to give them proper shape. In formative years, trees may be pruned to have one main trunk clear of branching up to about 1 m. After that, they assume a desirable rounded canopy shape naturally. When the graft has branched too low, the process of training becomes very important. At least 75 cm of the main stem should be kept free from branching and the first leader/main branch may be allowed after that. The branches which exhibit tendency of crossing and rubbing each other should be removed in the pencil thickness stage, otherwise they break by rubbing each other at a later stage and create complications. By following the above practice and after giving proper shape to the trees, there will be much less scope for future pruning except removal of diseased, pest infested or dried shoots/wood. More importantly, the few fruits set in a tree's first years of fruiting should be removed to speed up tree development.

Mangoes are considered self-fertile and do not require pollinators, but research indicates that some cultivars are self-unfruitful or at least benefit from cross-pollination. Fruit set is generally just a few percent, with an average of only one mango per panicle.

9.4 IRRIGATION REQUIREMENTS:

Amount and frequency of irrigation depends upon the type of soil, prevailing climatic conditions, especially rainfall to be given and its distribution and age of trees. Irrigation should start when the weather warms up. Continue every one to two weeks, more often in light soils, nearly continuously in areas where soil water retention is low. Irrigation may be discontinued when rains are sufficient to maintain soil moisture.

During the first year when the plants are very young with shallow root system, they should be watered every 2 to 3 days in the dry season. Trees in the age group of 2 to 5 years should be irrigated at 4 to 5 days interval. The irrigation interval could be increased to 10 to 15 days for 5 to 8 years old plants during dry season. Although hot, dry weather is favorable to fruit development, supplementary irrigation between flowering and harvest is advisable for good yields.

Generally, intercrops are grown during the early years of plantation and hence frequency and method of irrigation has to be adjusted accordingly. It is advisable to irrigate the mango plants in basins around them, which can be connected in series or to the irrigation channel in the centre of rows. The intercrops need to be irrigated independently as per their specific requirements. In mono-cropping of mango, basin irrigation is preferable with a view to economize water use.

9.5 FERTILIZATION

Soil fertility has a direct effect on all aspects of crop growth and development. In some cases, post-harvest disorders can be linked directly to the deficiency of a particular mineral, but often other environmental factors such as water stress are involved. “Spongy tissue” symptoms in mango have been linked to mineral deficiency and copper and iron deficiencies cause abnormal peel development in the fruits.

Mango trees require regular applications of nitrogen fertilizer to promote healthy growth flushes and flower production. Organic fertilizers perform best, since the trees are subject to fertilizer burn. Young trees are particularly sensitive to over-fertilizing. Sandy soils require more fertilizer than loam or clay.

The idea of applying manure to fruit bearing trees is also to secure regular fruit production. Application of 50 kg well-decomposed organic manure should be given each four year to create proper soil physical environment.

Fertilizers may be applied in two split doses, one half immediately after the harvesting of fruits and the other half 3 to 4 months later, in both young and old orchards, followed by irrigation if there are no rains. Supplemental N and foliar application of 3 percent urea in sandy soils is recommended before flowering, when vegetative growth flushes rather than flowering occur. Slow-release fertilizer formulations are preferred, except for supplemental N applications, which should have rapid release.

The mixture of recommended dose of fertilizers should be broadcast under the canopy of plant leaving about 50 cm from tree trunk in old trees. The applied fertilizer should be incorporated well up to the depth of 15 cm soil. To increase fertilizer use efficiency, fertilizers should be applied in 25 cm wide and 25 to 30 cm deep trenches dug around the tree 2 m away from trunk.

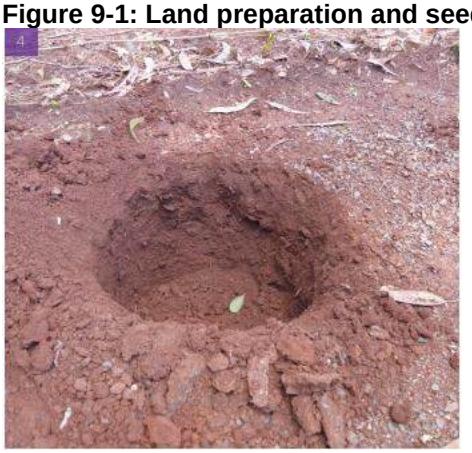
9.6 PRUNING:

Healthy trees require little pruning, although pruning to stimulate new growth promotes uniform annual bearing. Removing some flower clusters during a heavy bloom year may also alleviate alternate bearing.

Developing trees should be trained to eliminate low branches less than 1 m from the ground, leaving three to four main branches on the trunk at different heights. Pruning of well-formed older trees is usually confined to removal of dead branches. Pruning is preferably done after fruiting, before a growth flush occurs. Pruning can also be done to restrict tree size for small yards/orchards or when more than 51 trees per hectare are planted.

In the tropics mango trees trend to be extremely vigorous. The tendency is to want to reduce the size by heavy pruning but this can be detrimental to yield for several seasons after pruning. This is primarily due to the lack of a growth check, e.g. cold temperatures. Light pruning of trees in the tropics just prior to flowering (see tip pruning: flowering and fruiting) has shown promise.

Figure 9-1: Land preparation and seedling Planting



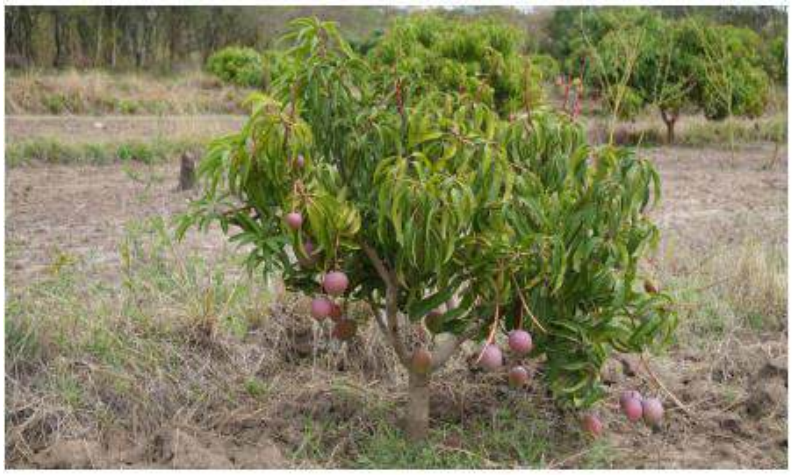
Pit preparation.

Mix the soil with farm yard manure thoroughly at the ratio of 3:1 respectively

Remove the seedling from the tube with its soils by holding it at the base of the stem

Place the seedling in the hole. Half fill the hole with top soil and press it gently towards the root

Make a basin around the base of tree by gently pressing down the soils



Matured mango plant