Africa RISING – NAFAKA Project
Compendium of Vegetable Production Training Protocols



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Published by International Institute of Tropical Agriculture

June, 2017

www.africa-rising.net

The *Enhancing partnership among Africa RISING, NAFAKA, and TUBORESHE CHAKULA Programs for fast tracking delivery and scaling of agricultural technologies in Tanzania* is an interdisciplinary and inter-institutional project that aims to address smallholder farmers' needs in the semi-arid and sub-humid zones of Tanzania. The 3-year project is funded by the USAID Mission in Tanzania as part of the U.S. Government's Feed the Future initiative.

Through participatory and on-farm approaches, candidate technologies are being identified and evaluated for scaling by the project team. This is being achieved through the already established networks by Tanzania Staples Value Chain (NAFAKA), Tuboreshe Chakula (TUBOCHA), and other institutional grassroots organizations, creating an opportunity for mainstreaming into wider rural development programs, beyond Africa RISING's current zones of influence.

The project is led by the International Institute of Tropical Agriculture (IITA) and the USAID Tanzania mission-funded programs NAFAKA and TUBOCHA. Developmental activities addressing the project objectives are being implemented in Manyara, Dodoma, Morogoro, Iringa, and Mbeya Regions in Tanzania.

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This document was made possible with support from the American people delivered through the United States Agency for International Development (USAID) as part of the US Government's Feed the Future Initiative. The contents are the responsibility of the producing organization and do not necessarily reflect the opinion of USAID or the U.S. Government.

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Introduction

AVRDC has been subcontracted by the International Institute of Tropical Agriculture (IITA) to promote vegetable production, consumption and marketing in the project 'Enhancing Partnership among Africa RISING, NAFAKA and TUBORESHE CHAKULA Programs for Fast-tracking Delivery and Scaling of Agricultural Technologies in Tanzania' (AR_NAFAKA).

AVRDC has long-term substantial experience in introducing elite varieties of vegetables worldwide. Through activities being implemented in the Babati District by 'The Africa Research in Sustainable Intensification for the Next Generation (Africa RISING)' program, improved varieties of tomato (Tengeru 2010 and Tanya), African eggplant (Tengeru white and DB3), amaranth (Amaranthus spp., Madiira I), African nightshade (Nduruma), and Jute mallow (SUD 2) were introduced to farmers with great success. Farmer-managed cross-sectional demonstration plot evaluation data from four villages in the Babati District show that farmers have increased their tomato production from 35.6 t/ha to 58.0 t/ha, African eggplant production from 35.9 t/ha to 69.5 t/ha, and amaranth production from 51.5 t/ha to 72.2 t/ha.

In collaboration with other key partners of Africa RISING in Tanzania, AVRDC and HORTI-Tengeru are working closely together to scale up technologies and skills in vegetable crop production, marketing and consumption. Specifically in this project, AVRDC and HORTI-Tengeru introduce and promote improved varieties, enhance vegetable nursery systems for smallholder farmers, improve household nutrition and postharvest-handling of the vegetable products, and engage in community development through promoting of vegetable production and consumption.

Results from the demonstration plots have shown that on an area of only 12 m^2, a household with five members can produce enough vegetables to meet the amount recommended by the World Health Organization of 200 g of vegetables per person and day. In addition, increased vegetable production in the four project villages of the Babati District generates a household income of 59.4 USD/season. Of particular importance to the Africa RISING program is the training on healthy seedling technologies. Using properly managed seedling nurseries, beneficiary farmers in the Babati District have significantly increased seedling vigor and reduced seedling mortality, ultimately leading to better harvests and higher incomes. Coupled with training on 'Good Agricultural Practices (GAP)', which are equally key to the realization of farmers' yield potential, these elite varieties are currently being scaled up either as single crops and/or intercrops with staple crops.

Project locations

During the first and second year of the project, AVRDC and HORTI-Tengeru jointly implemented activities in three target districts: Babati District (Maweni, Endadosh and Sangara villages), Kiteto District (Kaloleni, Kibaya and Sunya villages) in the Manyara Region, and Kongwa District (Chamkoroma, Tubugwe and Songambele villages) in the Dodoma Region. In the Morogoro region the project works in the Kilombero District (Kisawasawa, Ichonde and Misufini) and in the Iringa region the project established pilot activities in Luhindu, Lukani, Mtitu, Mbigili, Kalenga, and Mangalali villages.

Learning goal of the training manual

- Farmers should be able to understand the importance of using quality seeds of improved varieties and healthy seedlings and use it to boost vegetable production
- Farmers should be able to practically know and apply good agricultural practices (GAPs) right from nursery management to harvesting, i.e. land preparation tillage and soil treatment, preparation of sowing beds such as raised or sunken, sowing, transplanting procedures and proper timing, improvement of soil nutrient and texture through addition of recommended amounts or proper combination of manure and inorganic fertilizer, proper irrigation, mulching, proper spacing, timely pest and disease control/management through application of integrated pest and disease management (IPM) principles as well as proper harvesting
- Farmers should also get an opportunity to test vegetable seed kit recipe at the end of each learning season where the cooking show and organoleptic is organized per village in each demonstration site

Methodology for AVRDC-ESA technology scaling

Project activities at village level always start with a community needs assessment followed by an intensive sensitization meeting (awareness creation campaign) that includes information about the importance of vegetable production and consumption. After the sensitization meeting all training participants receive a hand-out summarizing important aspects of production, consumption and postharvest handling of vegetables. The sensitization activities are followed by a session on group governance and group dynamics to prepare all participants for a season-long training-of-trainers (TOT) training.

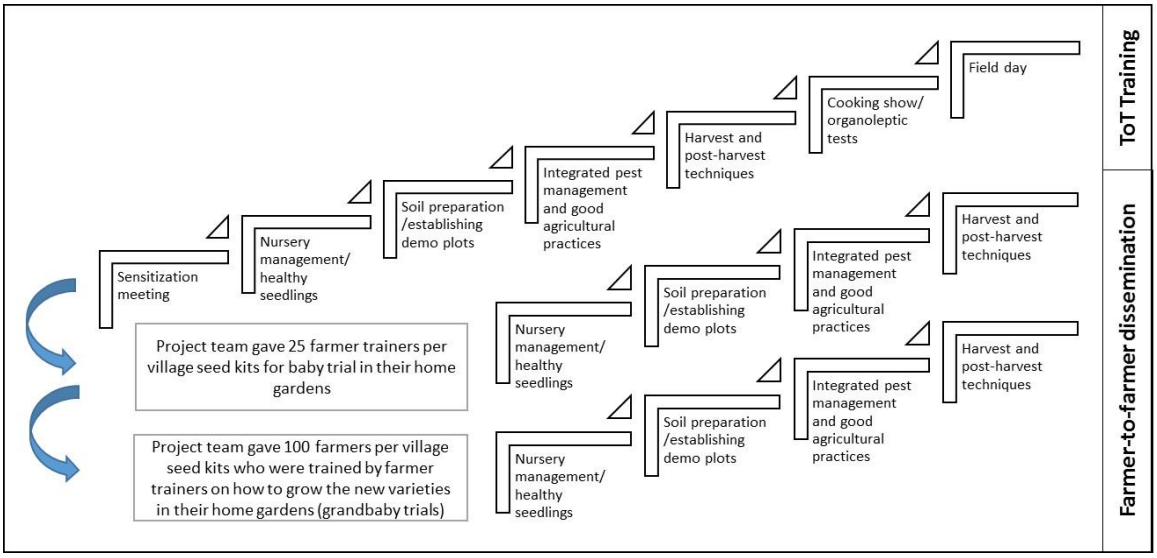


Figure 1: Capacity building approach

The project team chose a combination of ToT-training, farmer-to-farmer extension and field days (figure 1). Farmer trainers were trained on different practices of a vegetable production season including nursery management, transplantation, soil preparation, IPM practices, postharvest handling and food preparation. Training sessions took place every month within the 8-months season long production training on the mother demonstration plot. While establishing the demonstration plot together with the farmer trainers, the latter were given a seed kit to set up a baby trial in their own home gardens, parallel to the demonstration plot activities. The farmer trainers were further encouraged to invite 3-5 other farmers from their village to participate in an introductory training session on the local demonstration plots. Those secondary beneficiaries received a seed kit as well, but were trained by the farmer trainers while the latter established their own home gardens based on the knowledge and skills gained during the ToT-training. The home gardens established by the participants of the farmer-to-farmer trainings were called grandbaby trials. Field days were conducted to disseminate the information and technology beyond pilot village boarders (inter-village dissemination). Training farmer trainers aimed at internalizing the new technologies in the village community, while inviting village extension officers and other NGO field agents to attend the ToT-trainings aimed at internalizing the new technologies in knowledge institutions that are active across a larger area not covered by the pilot villages.

Module 1: Establishing a vegetable demonstration plot

Overview:

A demonstration plot is the practical location where all vegetable good agricultural practices (GAPs) are displayed to farmer's trainers and villagers in the target location. This helps to implement the idea of "SEEING IS BELIEVING" where each farmer participant is able to see the difference in practice of every procedure and ask the team of experts questions and to be informed of updated vegetable production practices from recent research outputs.

Duration:
One day per village

Training materials:
A 10 X 20m plot with access to good irrigation system, sisal rope, hand hoe, rake, manure-compost or farm yard, tape measure, protective gears

Field Layout
In order to establish the mother demonstration plots, one group member donates the land that will be analyzed to ensure that it fulfills the basic demonstration plot criteria:

- Soil for vegetable production needs a high content of organic matter. The type of soil is also important. Sandy soil is best for fast growing vegetables and silt loam soils are ideal for most of the vegetables.
- Water availability – water source for irrigation
- Be aware of the site history (previous land use); Taking into account the prior use of land e.g. previous crop, pest disease, weed levels and the potential impact of the production on adjacent crops and the adjacent area.
- Accessible by people/ target population for display (closed to main road)

All demonstration plots are created according to the following design (Figure 2).

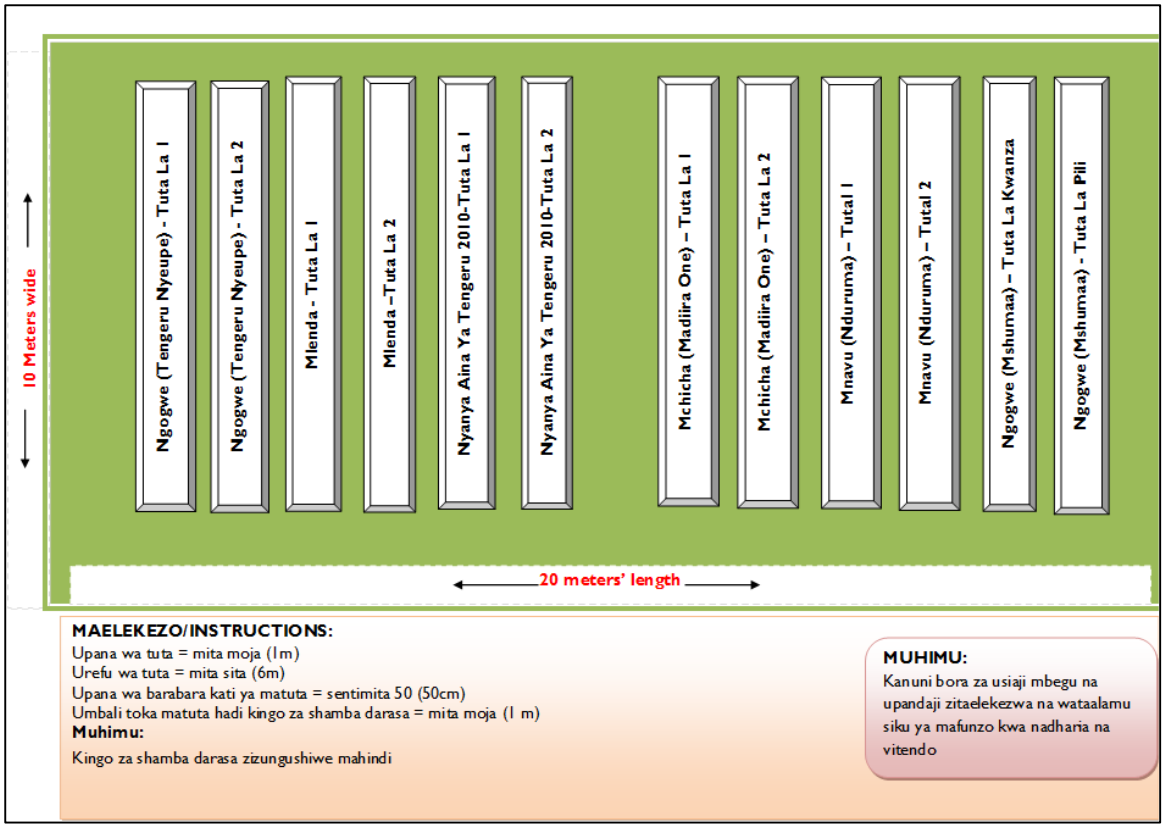


Figure 2: Africa RISING Partnership with NAFAKA and TUBOCHA programs; mother demonstration layout

The following sections discuss the content of the training sessions conducted during the season long TOT training activities:

Planting

Nursery preparation

For the nurseries, horizontal beds of 1 m width and 6 m length are established. The nursery beds should be raised by 15 cm to avoid damages from floods during the rainy season. It should also be free from shade when the demonstrations are conducted in the rainy season. Shade during the dry season in contrast can prevent the seed bed from drying out and may reduce wilting of young plants. The land should be well prepared and mixed with cattle, chicken or compost manure at a rate of 2-5 kg/m^2. Particular attention must be paid to protecting the nursery against insect pests, soil diseases and nematodes, whiteflies and other vectors of viruses (e.g. aphids and thrips).



Sowing methods

Direct sowing on ridges or raised beds. Sowing can be done by drilling or broadcasting. Most of the traditional vegetables are direct seeded. Seeds mixed with sand 1:4 ratios to make them easier to sow evenly. A seedbed is 1 m wide. For Solanaceae such as tomato and African eggplant, demonstration plots should have not be cultivated with tomato, nightshade or sweet pepper over the three of years. Seeding should consider a space between seeds of 1 cm and a space between rows of 15-20 cm at a depth of 0.5-1.0 cm. Watering is required before sowing. Seeds will be covered with soil thinly/lightly. Thinning of seedlings is usually done after 2-3 weeks when plants have between 3-4 leaves. Weeding needs to be done as soon as possible especially when the plants are still young.

Using trays: Seedlings can be raised in **trays** filled with healthy soil medium (peat moss) with a maximum sowing rate of 2 seeds per hole at a depth of 0.5 cm. Studies confirm that the use of better potting mixtures (healthy soil medium) and seedling trays reduce root diseases and increase plant vigor in Tomato and traditional vegetables. Seedlings will be thinned 3 days after the appearance of the first true leaves. In order to boost the initial seedling growth, starter solutions are applied at a rate of 10g per 10-15 liters of water between day 9 and 11 after seedling appearance. This will be followed by a daily dose of water for 3 days at a rate of 7.5-10 ml per hole. NPK foliar fertilizer (15-10-15 +2MgO) should be applied twice before transplanting between day 11 and 21 at the rate of 5 ml per seedling. Watering should continue until transplanting. Seedlings will then have hardened before transplanting in the fourth week.





Transplanting and crop management

The seed bed needs to be kept moist and seedlings need to be thinned to avoid damping off. Transplanting takes place about 4-6 weeks after sowing when plants have 4-7 true leaves. Plants benefit from cow or chicken manure at a rate of 0.2-0.5 kg/hole. NPK in each variety and in each replication (16N:16P:16K) will be applied one week after transplanting at the rate of 200 kg/ha. Urea (46%), at the rate of 120 kg/ha, will be top dressed in two split applications, first split apply together with NPK one week after transplanting, and the second at flowering stage. In the following we discuss the transplanting of the three main vegetable crops.

Amaranth:

The nursery should be in flat fertile soil close to a water source but not in a shaded area to avoid diseases and producing spindly seedlings. Soil should be well prepared and mixed with cattle or chicken manure or compost at a rate of 2-5 kg/ m^2.

Sowing depth: The fine seeds should be mixed with sand (at a ratio of 1:3) to make them easier to spread evenly, and sown at a depth of 0.5 to 1 cm in rows 20-30 cm apart, or by broadcasting onto the bed. Cover the seeds with a thin layer of soil followed by watering.

Tomato:

Seeds are sown 15-20cm between rows and 0.5 cm deep. Seedlings will emerge within 8 days at the optimal soil temperatures of 20-30°C. Seedlings grown in trays with individual containers are healthier and more vigorous compared to those grown in flats or beds. Seedlings grown in flats or beds suffer root damage when the plants are pulled out for transplanting.

Seedling tray method. Holes are filled with a medium that drains well, such as peat moss, commercial potting soil, or a mixture of sand, compost. Place the trays on benches in a sheltered place. Sow 2 seeds per hole and thin the seedlings 2-3 days after the first true (non-cotyledon) leaves appear.

Seedbed method. Choose a well-drained area not recently cropped with a solanaceous crop. Burning a 3-4 cm layer of rice straw on the seedbed before sowing and forming a raised seedbed of 15 cm or higher to improve drainage might reduce soilborne disease problems.

Cover the bed surface with a thin layer of compost or rice straw mulch. Do not allow the soil to dry and form a crust on the surface that might hinder seedling emergence. Water the seedbed regularly so that it is moist but not waterlogged. Thin the seedlings 2-3 days after the first true (non-cotyledon) leaves appear.

At the 2-leaf stage, irrigate the seedlings once with a 0.5% ammonium sulfate solution (5 g ammonium sulfate dissolved in 1 liter water), 0.25% urea solution (2.5 g urea dissolved in 1 liter water), or 0.1% Do not over-apply nitrogen or the plants will grow tall and spindly. Seedling death (damping-off) or poor growth can be due to fungal infection. Fungicides such as Ridomil Gold (mefenoxam) can be applied to the seedbed at or before seeding to control pythium damping-off. Seed can be treated with broad-spectrum fungicides, such as captan and/or thiram to reduce losses from damping-off.

Insects, such as whiteflies, thrips, and aphids, can transmit viruses to young tomato plants. Admire (imidacloprid) is effective as a seed, soil, or foliar treatment for these insects. If whiteflies are a problem in the nursery, we recommend that tomato seedlings be covered with a net, 60-mesh or finer, to prevent insect infestation

<u>African eggplant</u>
Nursery preparation and characteristics: Land should be ploughed well, mixed with cow dung, chicken or compost manures at a rate of 3-5 kg/m^2. The nursery should be in a flat area, with well drained fertile soils, free of shade, near to a water source. It should not have previously grown crops such as tomato, nightshades or sweet peppers over the last couple of years. Diseases left over in the soil from these crops can damage young African eggplant seedlings.
Seeds should be sown in rows, 15-20 cm apart with 1 cm spacing between seeds within a row. After sowing, cover the seeds with a thin layer of soil followed by watering. Thin the seedlings down to 1-2 cm spacing between plants. Weeding should be done whenever necessary to avoid competition with seedlings. Regular watering is also necessary.

<u>Ethiopian mustard</u>
For ***demonstration plot***: Transplanting into a plot of 4 rows, each 6m long (15 plants per row) at 40cm between plants and 60cm between rows
Ethiopian mustard is a small seeded crop and requires a leveled fine seedbed for optimum germination. Propagation method for Ethiopia mustard is normally by seed.
Seedbeds are normally raised above the soil to reduce the incidence of damping off. The top layer is dug and some well-decomposed manure is worked in to produce a friable soil. Seeds are drilled in the nursery in lines 15-20 cm apart. Watering in the nursery should be done with a fine rose. Cover the seedbeds with long grass or similar material to keep the surface moist and dark. When the cotyledons have spread after germination, this mulch is removed or placed next to the plantlets. Seedlings can be transplanted at the 4-leaf stage when seedlings are about 7-8 cm high, about 5 weeks after germination. When seedlings become too tall, they may become spindly and unlikely to develop into strong plants.

<u>African nightshade</u>
Seeds should be sown in rows that are 10-20 cm apart, and should not be buried more than 2 cm deep. Placing the seeds too deep will result in poor germination. Alternatively, seed may be broadcast and covered with a thin layer of soil. Seeds may be mixed with sand, fine dry manure, soil or ash to spread them more evenly during sowing.
Dry grass mulch can be applied, and removed when seedlings are about 3 cm tall. Seedling emergence takes 5-9 days under favorable conditions, or longer when soil moisture is inadequate. Seedlings are ready to transplant 3 to 4 weeks after emergence, and should be hardened by reducing the frequency of irrigation in the week prior to transplanting. Transplanting operations should be in the afternoon or under cloudy conditions to minimize transplanting shock

Jute mallow

To ensure compliance with good agricultural practices in nursery management, it is recommended that farmers till the soil properly before preparing raised beds and apply 20 g/m² of NPK (10-18-18) or 2 kg/m² of organic manure made of poultry droppings.

Seeds are sown on the beds in lines and are separated from each other by a distance of about 10 cm. Beds can be covered with well dry leaves for 15 days after sowing, and must be regularly watered. Seedlings are transplanted between 25-30 days after seed sowing at true leaf stage (15 cm of height).

Pumpkin leaves

Prepare the land to ensure establishment of a uniform stand. Early land preparation also allows time for weed seeds to germinate, allowing for early cultivation to destroy young weeds. Pumpkins are generally grown on raised beds (15 to 20 cm high). Final spacing of the beds in furrow irrigated culture is generally 2 m center-to-center.

Grass mulch is sometimes used for pumpkin production primarily for weed control, to keep fruit clean, and for moisture conservation since earliness is not a big issue. Planting is by direct seeding or occasionally transplanting.

Seeds should be planted to a depth of 2 to 4 cm. To achieve the maximum stand, plant two to three seeds per hill and thin to a single plant, leaving only the healthiest seedling.

Vegetable soybean

Prepare 20 cm raised beds and sow the seeds directly in the field with spacing of 50 cm between rows and 5-10 cm between plants within rows. Two to three seeds are sown in each hill (a group of plants coming from one hole is called a “hill”)

Module 2: Crop and field management

Overview:
Crop and field management is an important aspect of vegetable production to ensure full attendance of the crops in the field and be able to do the needful timely and properly. Vegetable crops require great attention from the first day of sowing through to harvesting as to supplying enough nutrients through timely addition of inorganic fertilizer in a recommended combination, proper irrigation and timely checking of any sign of destructive pests or symptoms of any disease for immediate action. Timing is crucial when dealing with vegetable crops.

Duration:
Throughout crop growth stages

Training materials:
Hand hoe, mulch, irrigation water, manure and inorganic fertilizers (DAP, NPK, UREA)

i. ***Weeding*** – early stage to facilitate crop growth and reduce competition with other plants. Keep the crop weed free, plus shallow cultivation and aeration of soil.
ii. ***Mulching*** – fill space between rows by using straw or other un-decomposed material, plastic. Mulching preserves water and provides supplementary nutrients.
iii. ***Irrigation*** – Most of the vegetables are sensitive to water deficit during the early stages of growth. The project recommends using watering cans as a low-cost and easily manageable irrigation method for smallholder farmers. Every time water comes in direct contact with vegetables, the possibility of contaminating the crop with pathogens exists. This includes also irrigation water. It is important to identify the source of the water.
iv. ***Fertilizer application*** – important for an optimal plant growth. It varies between crops, species and soil types. Good practices related to soil fertility improvement include maintaining and improving organic matter through appropriate crop rotation, manure application, rational mechanical and conservation tillage, maintaining soil cover to minimize soil erosion losses by wind and water, and the application of organic and inorganic fertilizers in appropriate amounts and timing.
v. ***Organic manure*** – Compost, cattle or chicken manure - 0.2-0.5 kg/hole or urea of 5 g/plant.
vi. ***Inorganic fertilizer*** - NPK (15-15-15) (250 kg/ha) for fruity vegetables and different combination for leafy vegetables as per amaranth NPK (10-10-20) (250 kg/ha). The fertilizers that will be applied in demonstration plots vary due to their availability/unavailability in the project area. Two different fertilizer application methods are applied:
    - Basal application – for incorporated manures, leaf biomass and phosphate fertilizers (the quantity depends on the type of fertilizer)
    - Top dressing – for Nitrogenous fertilizers
    - It is important to organize full traceability of fertilizer applications. The following records are kept during each fertilizer application:
        - name of the person responsible for fertilizer application,
        - plot size,
        - date of application,
        - type of fertilizer,
        - origin of fertilizer,
        - quantity applied, and
        - Method of application.

<u>Sowing</u>

a) Amaranth

10-15 cm space between plants (for leaf production) and 20-30 cm space between rows.

If sown in rows, seedlings should be thinned three weeks after sowing when they have 3-4 true leaves. Allow 10-15 cm between plants. If seed was broadcast, allow up to 5 cm spacing between plants.
This is most important when the crop is young or to avoid contaminating harvests when the whole plot is uprooted for sale. Amaranth grows rapidly and regular watering is necessary.

b) African eggplant

50 cm space between plants and 75 cm space between rows.
About three weeks after sowing, harden seedlings by slightly reducing the frequency of watering. The seedlings for transplanting are ready in four to six weeks or when they have 4-7 true leaves. The soil should be well prepared and if it is fertile the crop can be grown without fertilizer. In other situations mix in cattle or chicken manure, or compost at a rate of 0.2 -0.5 kg per hole. If manure is not available, CAN or urea fertilizers at a rate of 5 grams per plant can be used.

The recommended plant spacing for African eggplant is 75 cm between rows and 50 cm between plants in the row. Weeding should be done whenever necessary and watering during the dry season is very important. Additional top dressing with fertilizer after the third harvest improves subsequent yields. Red spider mites can cause problems during hot weather and damage shows up as dead leaves. Look for brownish patches under the leaves

c) Tomato

50 cm space between plants and 60 cm space between rows.

Seedlings need to be hardened by slightly reducing water and exposing them directly to sunlight 6-9 days before transplanting and thoroughly watered at about 12 hours before transplanting to the field. A good seedling is in the 4- or 5-leaf stage (about 4 weeks old), vigorous and stocky. Transplant in the late afternoon or on a cloudy day to minimize transplantation shock. Insert the seedling in a hole so the cotyledons appear above the surface. Press soil firmly around the root, and water around the base of the plant to settle the soil. Irrigate the field as soon as possible after transplanting. Plant spacing depends upon cropping system, soil type, and plant habit. But the normal spacing is 60 cm x 50 cm.

Shaping the land into beds and growing tomatoes on top of the bed facilitates furrow irrigation of the crop and drainage after heavy rain. Beds are made with a mechanical bed shaper and are about 1 m wide with furrows (ditches) 50 cm wide. Bed height varies with the season: 20 cm in the dry season and 35 cm in the wet season.

A mulch of rice straw, thin polyethylene plastic sheets, or other material is used to cover the soil surface. Mulches reduce fertilizer leaching, conserve moisture, and reduce weeds. If average air temperatures exceed 28°C, plastic mulch should be covered with rice straw to prevent it from getting too hot.

Tomato plants should be fertilized with organic (animal manure) and/or chemical fertilizers to produce high yields. The total N (kg per hectare) required to achieve a target fruit yield is estimated by multiplying the target yield in tons per hectare by 2.4. Requirements (kg per hectare) of P_20_5 and K_2O are estimated by multiplying N uptake by 0.35 and 1.45, respectively.
In the tropics, common fertilizer application rates are 60-120 kg N per hectare, 60-140 kg P_2O_5 per hectare, and 60-120 kg K_2O per hectare. It is recommended that half of the fertilizer be applied as a basal dose and the remaining fertilizer be added at first fruit-set.

Insufficient water at any growth stage will reduce yield and fruit quality. Tomato is most sensitive to water deficit during flowering, somewhat sensitive immediately after transplanting and during fruit development, and least sensitive during vegetative growth. Tomato grows well in moist but not soggy soil, and well-timed furrow or drip irrigation is effective. Wilting in the late morning indicates that the crop should be irrigated.

As a general rule in the dry season, irrigate weekly for the first month after transplanting, and then every 10 days until crop completion. The root zone of young transplants is shallow so irrigation should be frequent and just enough to recharge the root zone. As the crop develops, the root zone enlarges and less frequent but heavier irrigation is required. Tomato plants are sensitive to waterlogging and flooded fields should be drained within 1-3 days.

Staking or trellising tomato plants with bamboo poles or wood stakes provides support and keeps the fruit and foliage off the ground. Staking can increase fruit yield and size, reduce fruit rot, and ease spraying and harvesting. Indeterminate varieties should be staked to facilitate pruning, pinching, harvesting, and other cultural practices. Determinate varieties should be staked in the wet season to prevent fruit contact with the soil.

Weeds should be controlled in tomato crops because they compete for light, water, and nutrients. Sometimes they host tomato diseases, such as tomato yellow leaf curl virus. Mulches suppress weed growth on the beds. Remove weeds from furrows by pulling or hoeing.

d) Ethiopian mustard

Transplanting into a plot of 4 rows, each 6m long (15 plants per row) at 40cm between plants and 60cm between rows.

Generally, the *Cruciferae* family is a heavy feeder of soil nutrients. Ethiopian mustard being in the family of *Cruciferae* requires fertile soils with high organic matter. Ethiopian kale responds well to farm yard manure (FYM) but this is not always available. Instead, farmers may opt to apply inorganic fertilizers. In the case of FYM availability and depending on the level of soil fertility, as much as 50-60 t/ha is incorporated into the soil at land preparation stage. However, higher rates of FYM to the level of 150 t/ha have been reported in Tanzania. Most farmers find it easier to apply chemical fertilizers such as NPK or DAP in the planting holes or evenly broadcasted in the prepared field (basal application). Rates of about 100 kg N/ha and 75-100 kg P/ha are common practices. However, it is important to do soil analysis before fertilizers are applied. It is also important to top-dress with nitrogenous fertilizers such as urea or sulphate of ammonia (SA) 50 kg N/ha once per fortnight from the moment that leaf harvesting begins. Higher levels of nitrogen will increase proteins and enhance leaf production, whereas more phosphorous will enhance seed production potential. Some vegetable farmers will therefore increase the initial amount to 300 kg N, whereas others give a fortnightly side dressing of 50 kg N at a time. Fertilizer rate of 46/69 kg/ha of N/P_2O_5, respectively were found optimum in Ethiopia.

Two hand weeding at 25-30 and 50-60 days after sowing and a seed rate of 12 kg/ha were found with the best return of seed yield. Higher yields have generally been obtained when sowing was done not later than three weeks after the commencement of the main rains. Thus, optimum sowing date ranges from late May for the high altitude and cool areas of southeastern zone early to late June for the central highlands of Ethiopia. Studies on the effects of various technology packages on seed yield of Ethiopian mustard have demonstrated that an increase in seed yield ranging from 20-29% can be obtained by adoption of full technology package as indicated.

e) African nightshade

Transplanting operations should be in the afternoon or under cloudy conditions to minimize shock. Only strong and disease-free seedlings should be transplanted. Adequate water is required immediately after transplanting since the seedlings are sensitive to drought and good soil-root contact ensured by covering the roots properly with soil and applying slight pressure. Gap filling should be done as soon as possible to ensure a uniform crop. Shoot cuttings may also been used, whereby 20-30 cm cuttings from strong stems are inserted into well-watered and fertilized soil. Although cuttings result in a fast crop where harvesting starts after 3-4 weeks, the plants branch, spread and yield less; and contain more glycol-alkaloids compared to seed-propagated plants. Spacing may differ depending on the

species or variety, the intended crop duration, growing season, and whether the crop is for leaf or seed production. Wide spacing is generally used for seed production, and long/rainy season crops. For example, wider spacing during the long rainy season is recommended to allow sufficient air circulation, which reduces conditions favorable to the development of diseases. Recent studies found that leaf yield responded significantly to increasing planting density, with the highest plant density evaluated (10 plants/m^2) producing the highest leaf yield, but berry yield and seed yield did not differ significantly between various plant densities. Therefore, for leaf yield, the net benefit of increased plant density in achieving a comprehensive canopy and consequent high photosynthetic efficiency out-weighed the growth of individual plants, but was not beneficial for reproductive growth (berry and seed yield). Therefore a high plant density of 10 plants /m^2 was recommended for leafy crops; while wider spacing of 60x50 cm or 80x50 for berry/seed crops would not only be economical in terms of reduced inputs, but would encourage stronger branching and better quality.

f) Jute mallow

In the field, seeds can be sown on raised ridges or flat beds at 30-50 cm between rows and 25 cm x 25 cm from plant-to-plant within rows. Thin when seedlings are 7-10 cm high, leaving one plant/ hole spaced 25 cm apart. Dig cattle or chicken manure or compost into the soil for best results.

g) Pumpkin leaves

With proper care, pumpkins can be grown on most soils in Africa. However, for improved productivity, avoid low, poorly drained soils. Plant in well-drained, sandy loams with high levels of organic matter and a pH of 6.0 to 6.5. If irrigation is available, then raised beds should be used. To avoid potential soil-borne diseases and nematode problems, pumpkins should be planted in soils that have not grown a crop of watermelons, cucumber, muskmelons (cantaloupes), summer (zucchini) squash, or other member of the cucurbit family in the past 2 to 3 years. Pumpkins and squash tend to develop extensive root systems that efficiently explore the soil for water and available nutrients. For this reason, fertilizer requirements are moderate compared with many other vegetable crops. Timely and appropriate applications of fertilizer can make a significant difference in the quality and quantity of fruit produced. In the cool seasons, collect soil samples from each area you intend to crop and have a soil analysis performed on each sample. Soil testing eliminates much of the guesswork involved in a fertilizer program. If you do not have soil testing service available nearby, which is common in Africa, then apply enough fertilizer to supply 60 kg/ha of nitrogen. At 3 and 6 weeks after sowing, side dress 15 to 20 cm deep to the side of the plants with 22 to 34 kg/ha of nitrogen and 70 to 110 kg/ha of potassium. Optimal potassium levels will ensure good dry-matter production. Nitrogen (N) is the most commonly required fertilizer, although phosphorous is sometimes needed to promote good seedling vigor, maximum production and high fruit quality, especially in alkaline soils. Most mineral soils contain adequate potassium, but it may be deficient in areas with light soils. Phosphorus fertilizer is commonly placed in twin bands 15 cm deep and 15 to 20 cm to either side of the seed lines before planting. Banding of fertilizer near the seed is preferred over broadcast application since the rows are very far apart and in some cases making broadcast applications inefficient. Nitrogen is commonly applied in two side-dressings, the first at the 2-4 leaf stage and the second when vines start to develop runners. The goal is to grow plants with a large canopy of leaves, maintaining healthy leaves as long as possible. This can be done by maintaining adequate levels of fertilizer. However, care must be taken to not over-fertilize the crop, especially with nitrogen. *Excessive nitrogen favors vegetative growth over reproductive growth and can inhibit fruit set.* The nitrogen level must be low enough by the time of flowering so that the plant will form fewer new leaves after fruit begin to grow. This allows more sugars to go to the fruit, rather than to developing leaves and vines.

Pumpkins are generally planted from seed. The minimum, optimum and maximum soil temperatures for seed germination are 18, 35 and 38°C, respectively. Germination is slow and erratic when soil temperature is below 20°C. Fruit maturing when daily mean air temperatures are below 21°C have poorer quality. Pumpkins do well in hot weather, but very high temperatures (43-46°C) can cause

temporary vine wilting, sunburned fruit, and soft fruit at harvest with reduced shelf life. The spacing depends on whether cultivars are bush or vining.

Large fruited pumpkins are often planted in hills 1.8 to 2.4 m apart with rows 1.8 to 2.4 m apart also. Large acreages can be seeded in rows 1.8 to 3 m apart. Seeds are placed at 5 to 10 cm deep. In-row spacing of 15 cm are common and plants may be thinned to a final spacing at the 2- to 4-leaf stage. Fruit size may be modified by plant spacing. *Closer spacing generally produces smaller fruits and wider spacing generally results in larger fruits*. The number of mature fruits harvested per plant is usually low, and the weight of individual fruits varies widely from 0.5-10 kg, depending on species and cultivar. Under low input conditions, the yield is around 5 t/ha; with good care, a yield of 15 t/ha is reasonable. With improved hybrid cultivars a yield of over 30 t/ha can be attained. An average yield of leaves is 2 t/ha per 185 picking, or about 20 t/ha during a harvest period of two months. Growing under trellis system has been proven to give better yields than the open ground system. Preliminary studies carried out in Tanzania with *Curcubita moschata* sp. have shown that fruit yields of 10.6 t/ha can be realized under trellis system compared to 7.2 t/ha under open ground cultivation.

The traditional cropping system of pumpkin for leaves and/or fruit production is open ground intercropping in maize or sorghum fields. It is also planted on termite hills, fertile patches of abandoned homesteads and kraals. Monocropping is the appropriate system for commercial pumpkin production of improved cultivars, but in African countries this is still rare. To maximize land use under a pumpkin farming system, the trellis production system should be adopted with other crops planted in between the rows.

Pumpkins have extensive, moderately deep root systems that efficiently explore the soil for water. Pre-plant or post-plant irrigations should be applied to ensure seed germination, emergence and stand establishment. After marketing, irrigation is the second most important element of a successful vegetable production system. Sprinkler irrigation is frequently used during stand establishment, but this is not a good system once the vine canopy has become large, because it may result in significant vine and fruit disease. Furrow irrigation is the least efficient, least uniform, but is a common method of irrigation. In pumpkin, the most critical period for irrigation is while fruits are developing. In pumpkin, fruit size and yield are severely reduced by moisture stress. Any stress related to lack of water during fruit sizing can lead to the development of blossom-end rot.

Using grass or polyethylene (plastic) mulch offers growers several advantages. Plastic mulch increases the soil temperature, accelerating plant growth and development. It also conserves soil moisture and reduces several common problems, such as soil compaction and crusting, fruit rot on the ground, fertilizer leaching, drowning of crops, evaporation, and competition from weeds. Although using mulch will increase production costs, those costs are offset by increased profits from earlier and larger yields of high quality produce. Drip irrigation systems are recommended for use with plastic mulch.

For better weed control, select locations with low weed populations or no perennial weed problems. Use mechanical weed cultivation between rows, and employ practices which encourage rapid growth and development so as to fasten the process of developing a canopy. Consider using polyethylene or grass mulch as part of your weed control strategy

h) Vegetable soybean

Prepare the field with a mixture of compost and NPK fertilizers at the rate of 2-3 (N), 6 (P) and 8 (K) g/m^2. Irrigate the field 3-4 days before sowing to ensure sufficient moisture in the soil for good germination. Prepare 20 cm raised beds and sow the seeds directly in the field with spacing of 50 cm between rows and 5-10 cm between plants within rows. Two to three seeds are sown in each hill (a group of plants coming from one hole is called a "hill"). Irrigation is needed within a week after sowing. Depending upon weather and soil moisture conditions, the irrigation is continued at 10-15 day intervals

until the pods are well-developed. Maintaining proper soil moisture throughout the growing season is important for good quality pods, especially during flowering and pod-filling stages.

Module 3: Plant protection – pest and diseases

Overview:
The plant protection is done right after the seedling has emerged and is done throughout the crop growth stages so as to try to keep plants healthy and free from pathogens that might interfere growth and better yields. There is the combination of theoretical sessions and practical sessions which will equip the trainees with various plant protection skills. The theoretical session covers all aspects in the display form where farmers get to know Integrated Pest Management and have time to identify the symptoms of every destructive pest and disease, as well as learn the means to overcome and control the latter.

Duration:
Throughout crop growth stages

Training materials:
A class theoretical session to display pests and diseases, discuss IPM manuals with pictures of different pests and diseases, a practical visit to the demonstration plot to check possible pests and disease or to a farmer's vegetable field.

Control of different pests and diseases during crop growing is done based on Integrated Pest Management (IPM) as a pest management approach that uses all available environmentally friendly pest control methods, including but not limited to cultural, biological, physical and judicious use of pesticides, to optimize a crop's ability to resist the pest with the least hazard to man and the environment. Integrated means mixing different methods together to get the best solution. This includes:

i) **Cultural methods**: include crop rotation, soil tillage, use of trap crops, and change in planting or harvesting time, intercropping with other crops or with varieties that repel pests.
j) **Mechanical and physical methods**: techniques such as collecting insects with traps, physical barriers, sound barriers or screens.
k) **Biological control:** includes the uses of microbial pathogens (e.g., bacterium,) that generally attack a specific pest and the release of predators and parasitoids to control insect pests.
l) **Chemical methods:** where chemicals are used to eliminate the pests. The chemicals may be manufactured pesticides or natural extract from plants such as neem.

Crops are thoroughly inspected for disease at least once every seven days, and extension staff, farmers and trainers who are working in the crops have been trained in disease symptom identification. Where necessary, use of chemicals is kept to the minimum extent and used only within the framework of IPM. For tomatoes and African eggplant, Abamectin at a rate of 10 ml in 20 liters of water is applied to control insect pests such as spider mites. Ebony M 75 WP and Power 75 WP fungicides are applied at a rate of 59 grams in 20 liters of water to control fungal disease such as early blight and late blight in tomato. Other chemicals that can be applied depending on the magnitude of the effect based on certified agro dealers. Cautions are always taken as chemical pesticides are subject to change periodically.

i. **Whiteflies** (Scientific name _ *Bemisia tabaci* (Inzi weupe in Swahili)

Recognize the problem
White flies are 2 mm small and usually sit underneath of the leaves, and fly off when you shake plants. They extract sap from the undersides of the leaves but are mainly problematic because they transmit tomato diseases (viruses). To prevent virus diseases, early control is needed, but difficult in unprotected cultivation.

Prevention

- Do not plant seedlings nearby crops with whiteflies because of virus transmission.
- Remove weeds prior planting as weeds can harbor whiteflies.
- Destruct crop residues after harvest.
- Plant during or shortly after the rainy season.
- Use mulch after transplanting at dry weather.
- Intercrop with beans, cucumber, tobacco or maize to delay pest build –up.
- Plant tobacco as a trap crop because its flowers attract whiteflies.
- Plant Fenugreek (Trigonella spp.) and coriander which are repellent of whiteflies (be aware that coriander may attract aphids).

Monitoring

- Few flies per 10 plants may require direct control measures in early tomato growth stages in case that tomato virus problems occur in the area.
- If no major virus problem occur in the area, several whiteflies per each plant of a field can be tolerated.

Green direct control

- Spray nimbecidine botanical (Neem extract, Azadirachtin) max 3 times; Start spraying 15 days after transplanting (2.5-3 liters/ha or 50-60 ml /20 liters water) (Neem seed cake, seed powder also work).
- Liquid soap spray (stir 3 tablespoons liquid soap, e.g. Cera-liquid, with 4 liters water) is effective in the morning during wet weather. Spray every week on young plants as long as you see whiteflies.
- Flour spray (stir 2-4 tablespoons maize, cereal or potato flour in 4 cups warm water, then 1 tablespoon soap, stir, filtrate or 0.15 liter flour + 0.05 liter soap+ 10 liter warm water). Spray in the morning.
- Chop 30 to 40 hot peppers or 0.6 liters hot pepper powder into 10 liters warm water (not boiling); Let liquid steep for 24 h. Remove pepper rests and dilute with 10 liters cold water; Add 20 (0.001 liters) drops of dishwashing liquid (soap). Spray in the morning.
- Grind 50g wild basil leaves; soak overnight in 2-3l water; strain; add 10 g soap; spray in the morning.

Chemical direct control with restrictions

- Avoid spraying pesticides, because most are toxic. Thiamethoxam is slightly hazardous (pre-harvest interval 28 days). Amitraz and pirimi-phosmethyl are hazardous (WHO toxicity class II) and not suitable for IPM (only 2 sprays per season allowed, pre-harvest interval 35 days). Wear protective clothing.
- Spray only on young tomatoes. Spray directly on underside of leaves. Field entry restricted 3 days.
- In any case, do not accept products with class 1a, 1b, or red indications on labels, because they are very dangerous to you and consumers.

ii. Aphids (Scientific name _ *Aphids* (Kimamba/Wadudu mafuta /Vidukari in Swahili)

Recognize the problem

Aphids are soft and roundish insects sitting mainly underside of leaves or on twigs. A single aphid is almost too small to be seen, but groups of aphids can be easily seen. The aphids weaken the tomato plants. Many aphids can cause leaf curling. Plant diseases, such as tomato viruses can be transmitted. Aphids mainly damage young and vegetative stages of tomato plants.

Prevention

- A healthy crop tolerates aphids.
- Use more organic fertilizers than synthetic ones, then plant sap becomes less attractive.
- Grow maize rows around tomato field to pull flying stages of aphids out of the tomato field.

Monitoring

- When 5 plants of a < 50 m^2 field are strongly infested (several leaves full of aphids), then consider action.

Green direct control

- Liquid soap spray (stir 3 tablespoons of liquid soap, e.g. Cera-liquid, with 4 liters water) is effective during wet weather. Spray every week on non-fruiting plants as long as you see many aphids.
- Fill container ½ with marigold flowers (Tagetes spp.), stand and ferment 5-10 days with occasional stirs, strain fluid, add double water). Spray.
- Short strong overhead irrigations wash aphids away (be aware this may disperse diseases).
- Spray nimbecidine botanical (Neem extract, Azadirachtin) max. 3 times; Start spraying 15 days after transplanting (2.5-3 liters/ha or 50-60 ml /20 liters water) (Neem seed cake, seed powder also work).
- Ferment cow urine in drum for 14-21 days (you may add cow dung to make it slurry), filter, mix with water in the ratio of 1:14 and spray.
- Finally shop 85 g garlic bulbs, soak 1 day in 50 ml mineral oil, then + 10 ml soap, stir, then add 1 liter water, stir). Spray over plants max 2 times.
- Spray the biocontrol agent fungus Beauveria bassiana Strain GHA according to instructions on label.

Chemical direct control

- Green direct control measures are usually enough to control aphids in tomatoes and no chemicals are needed. If you still experience problems, then seek further advice.

iii. Bacterial spot disease (Scientific name _ *Xanthomonas campestris sp*, *vesicatoria,* Bacterial spot, (Doa bakteria in Swahili)

Recognize the problem

Bacterial spot is a disease that can appear on all growth stages. It causes small, water-soaked lesions on leaves and stems that turn dark and are often surrounded by a yellow ring. Raised or sunk black or brown specks on appear on fruits, sometimes surrounded by a white ring.

Prevention

- Use disease-free and clean certified seeds, because this disease can live in seeds.
- Select nursery sites away from tomato fields.
- Use furrow irrigation instead of sprinkler irrigation to reduced disease spread.
- Rotate tomatoes with other crops having at least 3 years tomato breaks. But do not use Solanaceous crops, such as potatoes, red pepper instead because they can also carry this disease.
- Avoid working in fields under wet conditions.
- Avoid injury to fruits.
- Keep volunteer tomato plants or other abandoned Solanaceae out of fallow fields.

Monitoring

- Immediate action is suggested after typical symptoms appear on leaves.

Green direct control

- Remove infected seedlings with roots and surrounding soil and burn or deeply burrow everything. Do not re-plant tomatoes into the same spot.
- Prune infected leaves and burn them. This disease is airborne and soil borne.

Chemical direct control with restrictions

- You may reduce further infections by spraying copper oxychloride or copper hydroxide. Both are toxic (WHO toxicity class II hazardous). Wear protective clothing. Spray earlier than at least 30 days before harvest.

iv. Bacterial wilt (Scientific name _ *Ralstonia solanacearum* Bacterial wilt, (Mnyauko bakteria in Swahili))

Recognize the problem

Bacterial wilt is a disease that can appear on all growth stages. It is first recognized by wilting of terminal leaves. 2 to 3 days later, the entire plant will rapidly wilt without any prior yellowing of the leaves. The infected base of stem becomes brown. When the infected stem is sliced and placed into a glass of water it produces a milky substance of exiting bacteria within minutes.

Prevention

- Use varieties with some resistance (Fortune Maker, Kentom, Taiwan F1).
- Avoid planting in low, wet areas or on fields with history of bacterial wilt.
- Interrupt tomato growing for several seasons with non-solanaceaous crops like cereals, beans, sugarcane, cabbage, (not red pepper, not potatoes).
- Avoid movement of tools/equipment's/water from contaminated soils to non-contaminated soils.
- Stake two weeks after transplanting and prune for better aeration (disinfect pruning knifes, e.g. with bleach, before working on next plant).
- Avoid furrow irrigation because this soil borne disease would proliferate (if using furrow irrigation then flow water from new to old fields to minimize spread of diseases).

Monitoring

- Already a single infected plant needs to be destroyed, and actions taken.

Green direct control

- Pull out plants with roots and surrounding soil and burn everything. But do not openly carry materials through your field, because this will spread the disease. Do not replant tomatoes into the same spot.
- Soak 50g grind fresh lemongrass in 2 liters water over 2 hours, filter, and spray reaching coverage of plants.

Chemical direct control with restrictions

- You may reduce further infections by spraying copper oxychloride or copper hydroxide. Both are toxic (WHO toxicity class II hazardous). Wear protective clothing. Spray earlier than at least 30 days before harvest.

v. Bollworm (Scientific name _ *Helicoverpa armigera*, Bollworm (Funza wa matunda in Swahili))

Recognize the problem
Bollworms, also called tomato fruit worms, are 2 to 4 cm long caterpillar larvae, and light grey/dark grey striped. You may spot small young larvae on leaves below the highest open flowers, and on green fruits, mainly around the stalk. Young bollworm larvae enter young tomatoes and start feeding. Therefore you will see a small, darkened hole at or inside the base of the tomato near the stalk (often under the base leaves of the flower). If you find a darkened hole, remove fruit and open to search for larva to confirm bollworm. Fruits decay or ripen too fast. Larvae sometimes feed on tips of flower buds and young leaves.

Prevention
- Avoid crop rotation or nearby planting of Solanaceae crops, e.g. red pepper, because they host bollworms.
- Avoid crop rotation or nearby planting of maize, sorghum, cotton if you know about bollworm populations in your area. Bollworms like these crops.
- In case of low bollworm populations in the area, grow one maize row as a border trap crop around tomato field.
- Remove fruits attacked by larvae (also fallen fruits), then destroy infested material by chopping into pieces or placing into sealed plastic bags into sun.
- Remove crop residues after harvest because bollworms pupate in there.

Monitoring
- Search on leaves below the highest open flower and on fruit bases. When the first few < 1 cm long larvae are detected, you may consider action. When you spot holes, sprays do not help because the larvae are already inside the fruits.

Green direct control
- Handpick small young larvae from young tomato leaves and flower bud tips.
- As long as the small larvae are still on flowers or outside fruits, you may consider sprays:
- Liquid soap spray (stir 3 tablespoons liquid soap, e.g. Cera-liquid, with 4 liters of water), or powder soap spray, reaching coverage of fruits and plants. Spray in mornings.
- Spray nimbecidine botanical (Neem extract, Azadirachtin) max 3 times (2.5-3 liters/ha or 50-60 ml/20 liters of water) (Neem seed cake, seed powder also work). Reaching coverage of fruits and plants.
- Chop 30 to 40 hot peppers or 0.6 liters hot pepper powder into 10 liters of warm water (not boiling); Let liquid steep for 24 h. Remove pepper rests and dilute with 10 liters of cold water; Add 20 (0.001liters) drops of dishwashing liquid (soap), reaching coverage of fruits and plants.

Chemical direct control with restrictions
Chemical control can only work as long as small larvae are still on flowers or outside fruits:
- Abamectin is once allowed at flowering stage. Pre-harvest interval 28 days.
- Diafenthiuron (WHO toxicity class III, slightly hazardous) max 2 / season. At least 28 days pre-harvest.
- Other pesticides are toxic to you (all WHO toxicity class II hazardous), and not suitable for IPM.

vi. Cutworm (Scientific name _ *Agrotis spp.* Cutworm (Sota in Swahili)

Recognize the problem
Cutworms are 2 to 4 cm long larvae, and dark grey-brownish (= soil colour). They are about 0.5 to 1 cm thick and soft. The older thus bigger larvae can cut and chew young tomato stems quickly.

Watch out for cuttings in your tomato nursery and on fields with freshly transplanted plants for a few weeks. Under a freshly cut seedling, you can often find a cutworm larvae in the soil.

Prevention

- Destroy weeds early as they are attractive to ovipositing female moths.
- Plough before and after cropping cycle to expose cutworms to predators.
- Intercrop tomato with onion or garlic every 10 to 20 rows to repel larvae.
- Prevent stems of tomatoes from cutworms with protective collars made of plastic/cardboard cups or plastic bottles pushed into soil around seedling.

Monitoring

- If you have experienced cutworm damage in previous season, then preventive measures must be taken.
- During mass outbreaks (= non-normal according to long year experiences =uncountable numbers) action must be taken.

Green direct control

- Hand pick larvae from the soil at night or early mornings
- Insert small vertical sticks during transplanting to enhance the diameter of seedling stem and therefore putting a physical barrier.
- Apply ash around the seedlings (mainly applicable in small plots).
- Chop 30 -40 hot peppers or 0.6 l hot pepper powder in 10 l warm water (not boiling); Let liquid steep 24 h; Remove pepper rests and dilute with 10 l of cold water; Add 20 (0.001 liters) drops of dishwashing liquid (soap). Spray in the evening directly to the soil around the stem of seedlings.

Chemical direct control with restrictions

- Avoid spraying pesticides, because there exist only toxic ones against cutworm (e.g. carbaryl, bifenthrin, WHO toxicity class II hazardous; not suitable for IPM). Wear protective clothing. Field entry restricted 1 day.
- If spray is needed, then spray in the evening directly to the soil around stems of seedlings. One spray / season. Pre-harvest interval at least 7 days.
- In any case, do not accept products with class Ia, Ib, or red indications on labels, because they are very dangerous to you and consumers.

vii. Damping off fungal disease (Scientific name _ *Phytophthora, Pithium*, *Rhizoctonia, Fusarium spp.* (Kinyaushi in Swahili))

Recognize the problem

Damping off is a fungal disease. Seeds may rot before germinating, and/or seedlings may decay before emergence, giving the appearance of poor germination. Damping-off also affects the base of the stems of seedlings and young plants, resulting in dark, water-soaked, soft lesions. Seedlings often wilt and fall over as a result of damage.

Prevention

- Avoid placing nursery in a shaded, humid place.
- Select nursery sites away from tomato fields.
- Transplant only disease-free seedlings.
- Remove and destroy infected plans.
- Ensure good ventilation through spacing of seeds (ca. 3 x 5 cm space) and stalking of plants.
- Ensure balanced fertilization.

- Avoid unnecessary irrigation as this favors the diseases. You may only irrigate early in the day to allow rapid drying of foliage.
- Disinfect seedling trays with bleach (NaOCl) before storage.

Monitoring
- When first symptoms appear on seedlings action is needed.

Green direct control
- Uproot and destroy diseased seedlings.

Chemical direct control with restrictions
- Once your seeds or seedlings are affected chemical sprays are of little help.
- You may slightly prevent further spread by spraying mancozeb (WHO toxicity class III, slightly hazardous; 30 days pre-harvest) max 2 times.
- You may slightly prevent further spread by spraying mancozeb combined with copper oxychloride and metalaxyl. These are however toxic (WHO toxicity class II hazardous; 30 days pre-harvest), and not suitable for IPM. Wear protective clothing.

viii. Early blight disease (Scientific name _ *Alternaria solani*, Early Blight Fungus (Bakajani tangulia in Swahili)

Recognize the problem
Early blight is a fungal disease. It causes brown irregular lesions with concentric zones on the leaves. Leaf tissues become chlorotic around the lesions, leaves dry up and drop. Moreover, black sunken, irregular lesions with concentric rings may appear on fruits near the fruit stem. Symptoms can be found on all the above-ground parts of the plant but most commonly on mature leaves. The disease starts from the lower, older leaves and moves upwards on the plant.

Prevention
- Use tolerant varieties (e.g. Duluti & Tengeru 97, 2010, Rio Grande)
- Use certified seeds as this fungus can be seed borne.
- Select nursery sites away from tomato fields, and do not place nursery site at the same place from season to season.
- Transplant only disease free seedlings.
- Remove and destroy plant residues and debris.
- Avoid spreading disease with water, humans, machinery. Do not work in the field during wet conditions.
- Ensure good ventilation (keep seedling and plant distances).
- Stake two weeks after transplanting and prune plants for aeration (disinfect pruning knifes or hands with bleach before working on next plant).
- Avoid unnecessary irrigation. If needed, only irrigate early in the day to allow rapid drying of foliage.
- Orient plant rows in direction of prevailing winds to increase ventilation.

Monitoring
- When first symptoms are detected action might be considered

Green direct control
- Remove and destroy diseased plant parts or leaves. But do not openly carry materials through your field, because this will spread the disease.
- During dry season, spray cow milk (this is not working in wet season).

Chemical direct control with restrictions

- You may prevent further spread by spraying chlorothalonil (follow instructions on label, 21days pre-harvest interval)
- You may prevent further spread by spraying mancozeb (WHO toxicity class III, slightly hazardous; 30 days pre-harvest) max 2 x. You may combine this product with milk.
- You may prevent further spread by spraying mancozeb combined with copper oxychloride, copper hydroxide and / or metalaxyl. These are however toxic (WHO toxicity class II hazardous; 30 days pre-harvest), and not suitable for IPM.

ix. Fusarium wilt (Scientific name _ *Fusarium oxysporum*, Fusarium wilt, Basal Rot (Mnyauko Fusarii in Swahili)

Recognize the problem

Fusarium wilt is a fungal disease, and also called basal rot. It causes foliar yellowing which starts on lower, mature leaves. It is often found on one side of a branch only. Most damage occurs on mature plants and the plants can wilt.

Prevention

- Use disease-free certified seeds, because this disease can live in seeds.
- Use tolerant/resistant (e.g. Fortune Maker, Rio Grande, Tengeru 97/2010, Roma VFN, Roma VF).
- Up to 5 years break in rotation and without other Solanacean crops, such as red pepper or Irish potato, to get largely rid of this soil-borne disease.
- Do not make compost and mulch from infected fields.
- Avoid injury of plants when working in the field.
- Sterilize tools and shoes in case fields are in a fusarium infected area (e.g. with bleach, which is NaOCl).
- If fusarium wilt detected in areas of your field, go to this area last after managing healthy plants.
- Avoid furrow irrigation because this soil borne disease would proliferate (if using furrow irrigation then ensure that water flows from new to old fields to minimize spread of diseases).

Monitoring

- Already a single infected plant needs to be destroyed, and actions taken.

Green direct control

- Remove and destroy entire diseased plant. But do not openly carry materials through your field, because this will spread the disease.

Chemical direct control with restrictions

- There is not effective direct chemical control measure available.

x. Late blight disease (Scientific name _ *Phytophthora infestans*, Late blight (Bakajani chelewa in Swahili)

Recognize the problem

Late blight is a mold disease. It causes initially small, water-soaked, greyish green, irregular lesions on leaves. Later they become dark grey and expand over entire foliage during moist warm weather. Stem lesions can girdle the plant causing death. Late blight may cause large brown leathery lesions on fruits.

Prevention

- Use tolerant/resistant varieties (e.g. var. Meru, Rio Grande, Tengeru 97, Duluti, Tengeru 2010, Shengena).
- Interrupt tomato growing (e.g. Tomatoes - Maize - Beans/Cowpeas/Sun hemp – Onions/Carrots/sweet potatoes - Tomatoes).
- Keep wide plant space (75 by 60 or 60 by 60 cm) to improve aeration.
- Stake and prune for aeration (disinfect knifes and hands with bleach before working on next plant).
- Remove crop residues and abandoned Solanecean plants.
- Plant away from infected fields and from Irish potato and red pepper fields.
- Avoid planting during wet and cool periods.
- Transplant only disease-free seedlings.
- Preventatively spray 0.5 kg ash mixed with 1 liter fresh milk and 10 liters water at dry weather conditions.

Monitoring

- During wet weather and when temperatures of 18 to 24 °C are forecasted, symptoms on 2 plants are enough to consider action
- When dry weather is forecasted, observe infection symptoms on plants. They can usually be tolerated and infected plants can be removed.

Green direct control

- Remove and destroy whole plants when diseased. But do not openly carry materials through your field, because this will spread the disease.
- Spray of 0.5 kg ash mixed with 1 liter fresh milk and 10 liters water at dry weather conditions.
- Mix 1 tablespoon baking soda with 1 tablespoon of vegetable oil and 4 liters water, then add ½tablespoon soap, stir, use immediately for spray
- Finely chop 85 g garlic bulbs, soak 1 day in 50 ml mineral oil, then add 10 ml soap, stir, then add 1 liter water, stir) and spray over plants max. 2 times

Chemical direct control with restrictions

- You may prevent spread by spraying chlorothalonil (follow instructions on label, 21 days pre harvest interval) max 3 sprays / season.
- You may prevent spread by spraying mancozeb (WHO toxicity class III, slightly hazardous; 30 days pre-harvest) max 2 x. You may combine this product with milk.
- You may prevent spread by mancozeb combined with copper oxychloride, copper hydroxide and / or metalaxyl. These are toxic (WHO toxicity class II hazardous; 30 days pre-harvest).

xi. Tomato leaf curl virus (Scientific name _ Tomato Yellow Leaf Curl Virus (TYLCV) (Virusi njano kujikunja majani, rasta, bondia, in Swahili)

Recognize the problem

Tomato leaf curl virus is a disease causing stunted young leaves and shoots. It can infect all growth stages but is most problematic in young stages. Plants grows slowly and becomes bushy. Yellowing and cupping of leaflets. Viruses are not transmitted by soil or air. They are transmitted by insects, mainly by whiteflies and to some extent aphids.

Prevention

- Use tolerant varieties (e.g. Tengeru 97).
- Remove volunteer tomato plants and abandoned or voluntary solanacean plants, such as red pepper.
- Preventively spray ½ liter milk with 9 liter water weekly at dry weather.
- Control the virus transmitting aphids and whiteflies if abundant.

Monitoring

- When infected plants are observed in the field, action might be taken.
- When aphids and whiteflies are abundant in seed beds or young plantings, then they need to be controled because they transmit the disease.

Green direct control

- Uproot and remove all heavily diseased plants.
- Control whiteflies:
  - Spray nimbecidine botanical (Neem extract, Azadirachtin) max 3 times; Start spraying 15 days after transplanting (3 liters/ha or 60 ml /20 liters water) (Neem seed cake, seed powder also work).
  - Liquid soap spray (stir 3 tablespoons liquid soap, e.g. Cera-liquid, with 4 liters water) is effective in the morning during wet weather. Spray every week on young plants as long as you see whiteflies.
  - Seek advice for other whitefly control and aphid control measures.

Chemical direct control with restrictions

- Viruses cannot be controlled by chemical pesticides because no effective viricides exist and viruses are hidden inside plants.
- Chemically control heavy white fly infestations particularly on seedbeds or young plantings.
  - Thiamethoxam is slightly hazardous (pre-harvest interval 28 days).
  - Amitraz and pirimi-phosmethyl are hazardous (WHO toxicity class II) and not suitable for IPM (only 2 sprays per season allowed, pre-harvest interval 35 days). Wear protective clothing.
- For further chemical control options against abundant whiteflies or aphids seek advice.

xii. Spider mite (Scientific name _ *Tetranychus spp.* Spider mites (Utitiri wekundu in Swahili)

Recognize the problem

Spider mites are tiny and hard to see. They usually attack the undersides of leaves. They cause tiny white yellowish spots on both leaf surfaces. Mites produce webbing that you can see. Strongly infested leaves are covered with fine webs may turn yellow and dry up. Mites may appear any time in tomatoes.

Prevention

- Remove and bury or burn all debris from harvested tomatoes as mites can survive up to 6 months in debris, or move to adjacent younger tomatoes
- Use slightly tolerant varieties (e.g. Roma VFN, RioGarde).
- Do not place field plots with young tomatoes next to plots with older tomatoes where mites can mass proliferate and migrate to younger plants.

Monitoring

- When first detection on several plants, one spray with Abamectin.
- When further infestations, e.g. 30% of plants, then consider further actions.

Green direct control

- Nimbecidine botanical (Neem extract, Azadirachtin) can be used max. 3 times; Start spraying 15 days after transplanting (2.5-3 liters/ha or 50-60ml /20 liters water) (Neem seed cake, seed powder preparations also work).
- Spray 2 % horticultural oil (1/3 cup oil in 4 liters water) in six week intervals. In older plants, spray after staking and pruning, to increase chance to hit mites.
- Irrigate to strengthen plants and reduce impact of mites' damage.
- Strong water sprays drop mites to ground where they can hardly survive.
- Garlic bulb oil spray (85 g fine shopped garlic soaked 1 day in 50 ml mineral oil, then add 10 ml soap, stir, add 1 liter water, stir) over plants max. 2 times.

Chemical direct control with restrictions

- Use only products declared acaricides as other pesticides may mainly kill insects and many natural enemies.
- Spray of Abamectin once allowed. Pre-harvest interval 28 days.
- Avoid spraying other pesticides, because there are only toxic ones against mites (e.g. amitraz, ethion, bifentrhin, profenofos + cypermethrin, dimethoate; all WHO toxicity class II hazardous; not suitable for IPM, only 1spray, pre-harvest interval 35 days). Wear protective clothing.
- Spray directly on underside of leaves and after staking and pruning to increase chance to hit mites. Field entry restricted 3 days.
- In any case, do not accept products with class Ia, Ib, or red indications on labels because they are very dangerous to you and consumers.

xiii. Tomato mosaic virus (Scientific name _ Tomato mosaic virus (Batobato in Swahili)

Recognize the problem

Tomato mosaic virus causes light green or mottled yellow leaves, with rough edges and pointed downwards. Mottled areas often appear thicker and elevated. Dwarfed plant are common. Fruit set is poor, and fruits have small brown streaks. Viruses are not transmitted by soil or air. They are transmitted by insects, mainly by whiteflies and to some extent aphids.

Prevention

- Use tolerant varieties (e.g. Kentom, Tengeru 97, Meru, Shengena).
- Use certified, disease free, clean seeds, because the virus can live inside.
- Do not smoke when handling plants, to prevent spread of disease
- Wash hands, cloths and tools with soap/ jink bleach (NaOCl)/ Tepool, to remove virus particles.
- Remove volunteer tomato plants and abandoned or voluntary solanacean plants, such as red pepper.
- Control the virus transmitting aphids and whiteflies if abundant.
- Preventively spray ½ liter milk with 9 liter water weekly at dry weather.

Monitoring

- When infected plants are observed in the field, action should be taken immediately,
- When aphids and whiteflies are abundant in seed beds or young plantings, then they need to be control because they transmit the disease.

Green direct control

- Uproot and remove all heavily diseased plants.
- Control white flies:

- Spray nimbecidine botanical (Neem extract, Azadirachtin) max 3 times; Start spraying 15 days after transplanting (3 liters/ha or 60 ml /20 liters water) (Neem seed cake, seed powder also work).
- Liquid soap spray (stir 3 tablespoons liquid soap, e.g. Cera-liquid, with 4liters water) is effective in the morning during wet weather. Spray every week on young plants as long as you see whiteflies.
- Seek advice for other whitefly control and aphid control measures.

Chemical direct control with restrictions

- Viruses cannot be controlled by chemical pesticides, because no effective viricides exist and viruses are hidden inside plants.
- You may, to some extent, kill virus near the surface of seeds. Immerse tomato seeds into 1 part of 10% Sodium hypochlorite : 9 parts water for 10 minutes.
- For chemical control of abundant whiteflies or aphids seek advice.

xiv. Root know nematodes (Scientific name _ *Meloidogyne spp*. (M incognita, M. hapla, M. javanica) (Minyoo fundo in Swahili)

Recognize the problem

Root knot nematodes are very small worms that cannot be seen by eye. They only live in the soil and in or on the roots. Numerous swellings (galls) can be seen on roots, which interfere with the flow of water and nutrients to the plant. This causes withering of plants particularly during warm weather. Plants appear less vigorous, may become yellowed and/ or remain small, and respond poorly to fertilizer. Fruit set is reduced.

Prevention

- Transplant seedlings with healthy roots, thus which are free of nematodes.
- Use tolerant varieties (e.g. Tengeru 97; Cal-J, Kentom, Meru, Roma VFN).
- Rotate tomatoes with nematode-non-susceptible crops (e.g. marigolds, sun hemp, brassicas, sorghum; be aware marigold might attract trips).
- Sterilize soil in nurseries by burning lots of dry wood and plant residue trash on top of seedbed, then incorporate hot material. Or apply boiling water over seedbed. Or remove topsoil and add compost to below soil.
- Change seedbed location from one copping season to the next.
- Use sufficient organic manure.
- Grow fallow during off-season, for example for livestock feeding.
- Plough directly after harvest prior fallow season to expose nematodes to drying.
- Incorporate dry chopped plants of wild marigolds (Targetes minuta) into the seedbed (be aware that fresh wild marigold inhibit germination).

Monitoring

- In case that more than half of the plants are infected in the field, actions should be considered.
- Green direct control.
- Make a 2 to 3 cropping cycle break with nematode-non-susceptible crops (e.g. such as marigolds and sun hemp or also cabbage crops).
- For small plots, incorporation of neem seed cake or powder into soil can help to reduce root knot nematode populations.
- Chemical direct control.
- There exist synthetic nematicides, but they are little effective and often highly toxic to farmers, concumers and the environement.
- Chemical fumigation of soils is not permitted in IPM.

xv. Powdery mildew (Scientific name _ *Leveillula taurica* Powdery mildew fungus (Ubwiri poda in Swahili)

Recognize the problem
Powdery mildew is a fungal disease. Mildew usually affects young developing shoots, foliage, stems and flowers, but can also colonise mature tissues. Mildews are recognised by the dusty-white to grey powdery-like coating particularly on upper side of leaves. Infected buds fail to open.

Prevention
- Avoid growing during cool dry season.
- No resistant variety yet, but variety Meru is more tolerant than others.
- Keep plant distances to avoid overcrowding.
- Prune regularly for good aeration (Disinfect pruning knifes and hands, e.g. with bleach, before working on next plant).
- Pot-Phos products improve plant growth, seed and flower formation, assist seedling establishment, and increases tolerance to powdery mildew.
- Avoid excessive nitrogen fertilization.
- Preventative spray of 0.5 kg ash mixed with 1 liter fresh milk and 10 liters of water, at dry weather conditions.
- Remove and destroy residues and debris at the end of the season.

Monitoring
- As soon as infection is obvious on several plants in your field, a preventive chemical spray may be considered once.
- When 30% of plants become infected, more control measures are needed.

Green direct control
- Remove and burn or deeply burry infected leaves.
- Mix 1 tablespoon baking soda with 1 tablespoon of vegetable oil and 4 liters water, then add ½ tablespoon soap, stir, use immediately for spray reaching good coverage of all leaves of plants.
- Finely chop 85 g garlic and soak for 1 day in 50 ml mineral oil, then add 10ml soap, stir, then add 1 liter water, stir. Then spray over entire plants, and this max 2 times per season.
- Chemical direct control with restrictions
- You may prevent spread by spraying mancozeb or hexaconazole (WHO toxicity class III, slightly hazardous) or benomyl. Spray earlier than 30 days before harvest. Spray maximum twice per season.
- You may prevent spread by spraying mancozeb combined metalaxyl, or by copper copper hydroxide, by triadimefon or triadimenol. These products are toxic (WHO toxicity class II hazardous), not suitable for IPM. Wear protective clothing. Spray only once - 30 days pre-harvest interval.

xvi. Thrips (Scientific name _ *Flower and leaf thrips spp*. (Vithiripi in Swahili)

Recognize the problem
Thrips are very small, only 1.5 mm long, elongate insect pests. They are light grey-greenish, but difficult to see -> Thrips feed by rasping the surface of leaves and sucking plant fluid. They cause tiny scars on leaves and fruits. Damaged leaves become papery and may curl and drop prematurely. They usually attack during the flowering stage of tomatoes.

Prevention
Plough deep to expose thrips pupae to predators.

- Irrigate regularly to reduce susceptibility of plants to thrips damage.
- Avoid planting tomatoes after onions (a host of thrips).

Monitoring

- When 5 to 10 plants per small <0.25 ha field are infected (look in flowers and on fruits), then consider action.

Green direct control

- Liquid soap spray (stir 3 tablespoons liquid soap, e.g. Cera-liquid, with 4 liters of water) is effective during wet weather.
- Plant Marigold (Tagetes spp.) plants around field as an attractive pull crop (attractive yellow flowers and long flowering period).
- Nimbecidine botanical (Neem extract, Azadirachtin) can be used max 3times; Start spraying 15 days after transplanting (2.5-3 liters/ha or 50-60 ml /20 liters of water) (Neem seed cake, seed powder preparations also work).
- Garlic bulb oil spray (85 g fine shopped garlic soaked 1 day in 50 ml mineral oil, then add 10 ml soap, stir, add 1 liter of water, stir) over plants max 2 times.
- Spray the biocontrol agent fungus Beauveria bassiana Strain GHA according to instructions on label.
- Chemical direct control with restrictions
- Avoid spraying other than above mentioned green pesticides, because heavy thrips infestation usually occurs late in the cropping cycle. Then sprays can poison the tomatoes ready for harvesting. At least 35 days pre-harvest interval would be needed.
- In any case, do not accept products with class Ia, Ib, or red indications on labels, because they are very dangerous to you and consumers.

xvii. Stem rot disease (Scientific name _ *Sclerotinia sclerotio*rum, Stem rot, Soft rot (Ukungu mweupe in Swahili)

Recognize the problem
Stem rot, also called soft rot or Sclerotinia, is a fungal disease at vegetative, flowering and ripening stage of tomatoes and causes rapid wilting with no prior foliar yellowing. White fungal growth is often present on the stem at the soil surface level or below. It can also attack foliage if the disease pressure is high.

Prevention

- Select nursery site away from tomato or potato or red peppe fields.
- Rotate tomatoes with non-susceptible crops, (e.g. onions, spinach, maize).
- Plough deep to bury Sclerotinia fungus.
- Remove crop residues and abandoned solanecean plants.
- Avoid frequent irrigation, particularly evening irrigation.
- Use furrow irrigation instead of sprinkler irrigation to reduce chances for spread of disease.
- Remove lower leaves from the plant and use stalking to increase aeration.
- Avoid fields with history of stem rot.

Monitoring

- Immediate action is suggested when first infected plant is detected.

Green direct control

- Remove infected plants with roots and surrounding soil and burn or deeply burry everything. Do not re-plant tomatoes into the same spot.
- Finely chop 85 g garlic and soak for 1 day in 50 ml mineral oil, then add 10ml soap, stir, then add 1 liter water, stir. Then spray over entire plants, and this max. 2 times per season.

Chemical direct control with restrictions

- There is no effective chemical control option against this disease

xviii. Weed control

Recognize the problem

There might be a number of non-tomato plants in your tomato fields. If they become too abundant, the may hinder grow of the crops and habituated dangerous pests.

Prevention

- Tillage twice before planting.
- Mulch after transplanting at dry weather (Mulching materials for weed suppression must be biodegradable).
- Crop rotation reduces weeds because certain weeds prefer to growth in certain crops only.

Monitoring

- In case that weeds outnumber tomato plants action should be taken.

Green direct control

- Conduct mechanical weeding, particularly in young tomato fields. Do not conduct weeding in tomato fields that are attacked by fungal or bacterial diseases, as this may spread the diseases.

Chemical direct control

- No synthetic herbicides are permitted in integrated productions, as they are too dangerous for humans, consumers and the environment.

Module 4: Harvesting and postharvest management

Overview:
This aspect is the most foregone in agriculture and it has cost implications. Proper harvesting is important both for the plant and the marketable product as it reduce plant disturbance and ensure lower rate of postharvest losses. It also ensures that harvested produce attract consumers. Proper harvesting practices such as means of cutting leaves or detaching fruits, harvesting regimes, timely harvesting, maturity indices, potential of shade in vegetable storage after harvest, value addition after harvest like solar drying are important for farmers to know. For example different harvesting regimes for leafy vegetables determine the yields and the number of harvests for the plant while maturity indices help guide the farmers as per the target market of the particular product, especially for fruit vegetables.

Recipe preparation equip farmers with best means of cooking different dishes of interest to their families from various vegetables in the seed kit. A badly cooked vegetable discourage most people from growing and consuming it, that is why vegetable recipes are important.

Duration:
One day per village

Training materials:
Knife, maturity indices chart, shade, solar drier, cooking utensils, recipes

Leafy vegetables can be harvested within 4-5 weeks after sowing. African eggplant is usually harvested 2 months after transplanting and the harvest can last up to 6-7 months. Tomato harvest starts two months after transplanting and continues for 6-8 weeks.

Observations/measurements
For Tomato and African eggplant yields/fruits quantities per plant are measured. Amaranths and other leafy vegetable crops – leaf yield per plant will be measured. For selected farmers the yield figures per plot will be collected. This includes detailed yield components such as the number of fruits per plant, weight of fruits and leaves per plot are measured.

Organoleptic tests
The harvest and postharvest training activities are followed by training sessions that aimed at sensitizing the participants on food hygiene and food safety issues. Organoleptic tests include the following topics: Sensitization of participants on hygienic practices during food preparation; guidelines on how to prepare vegetable meals while conserving the nutrient content of the vegetable crops; and introduction to cooking recipes covering nutrient-rich vegetables grown during the season long training.

a) Amaranth

Harvesting is usually done within 3-5 weeks after sowing, depending on the species. Pests and diseases are rarely a problem with such a quick crop. Weeds should be removed within the first two weeks to avoid competing with the crop and contamination of the harvest.
Long-term harvest by leaf plucking: Seed is best sown into a nursery bed and plants transplanted into the field 3-5 weeks after emergence. This ensures a high and even plant population and good plant vigor but delays the first leaf harvest. If plants are direct-sown the total leaf yield will be similar, but a more uneven plant stand is likely and this may have more weed problems. The nursery should be in flat fertile soil close to a water source but not in a shaded area to avoid diseases and producing spindly seedlings. Soil should be well prepared and mixed with cattle or chicken manure or compost at a rate of 2-5kg/m^2. Harvesting leaves is done every 4-5 weeks. The harvest can continue for 4

months, especially if local varieties are used. Once plants are older than 4 months leaf production falls and the quality of leaves deteriorates. In this case, the old established plants can also be chopped at the base to produce new edible sprouts.

b) African eggplant

Harvesting: Fruit harvest at consumption stage is due about 2 and half to 3 months after planting, whereas physiologically mature fruits also consumed in some countries occur one month later. The total lifecycle estimated for consumption maturity stage (130 days in average) is variable according to species, cultivars and cropping conditions.

c) Tomato

Harvest**:** Tomato can be harvested at different stages, depending upon distance and time needed to market the fruit. For long distance transport, fruit can be harvested at the breaker stage (not more than 10% of the surface is tannish-yellow, pink, or red). Fruit for local sale can be harvested at later ripening stages.

Poor care of fruit after harvest will lead to poor fruit quality. Avoid fruit injury and do not mix damaged and undamaged fruit. Harvest during cool periods, such as late afternoon or early morning. Shade the harvested fruit and avoid exposing fruit to temperatures higher than 25°C. If possible, store the fruit in a ventilated place with a relative humidity range of 85-90% to slow water loss.

d) Ethiopian mustard

As it has been stated earlier, Ethiopian mustard has dual utility (as vegetable and seed source for oil or other traditional purposes) and thus harvesting time and methods vary with type of plant part used. If the plant is used as source of vegetable, mustard leaf is usually harvested when the plants reached 30 cm tall (early harvesting) and 50 cm (late harvesting). New leaves will provide a continuous harvest until they are lignified and become too tough to cook.

Plants from seeds that were broadcasted at high density can be harvested by uprooting the whole plant 5-6 weeks after sowing. This method is normally used when the land is needed for another crop. For a conventional crop, the first harvest takes place about 5 weeks after 110 transplanting. Leaf harvesting is best done once in 2 weeks with 50% defoliation. Small leaved cultivars are often collected in the form of shoots rather than as individual leaves.

Postharvest management**:** While using Ethiopian mustard as vegetable, the quality of the harvested leaf is assessed based on the appearance, texture and flavor. Most of the time vegetables are consumed fresh without storing. The other option is to keep them for a few days in moist containers (1 or 2 days). If seed is important it should be kept stored in bags, sacks, clay pots or cans in dry, clean, cool and aerated stores. The seeds of Ethiopian mustard can maintain its viability for 15 years if it is stored under well-aerated and dry conditions. The leaves are rather perishable and wilt or become yellow when left on the shelf for more than a day. Farmers therefore harvest small quantities at a time. To retain freshness, the leaves are kept moist inside a bag that is left in the shade or in a cool place. When the product is offered as whole plants with roots, traders place the roots in water and plants can thus be kept for a few days.

e) African nightshade

Harvesting starts at 4-6 weeks age and the growers harvest by uprooting whole plants or picking young shoots and leaves to about 5 cm, allowing new side shoots to grow. Harvesting frequency may be 7-14 days for long season crops, but complete harvesting by uprooting is done during thinning, or when the crop needs to be cleared to make way for another crop.

Harvesting is done the evening before, or very early in the morning and marketed the same day. Minimal or no harvesting of leaves should be done on plants meant for seed production. The type of harvesting is thus important in influencing leaf yield and quality.

Additionally, the methods of harvesting may affect the market. For instance, uprooting means the consumer must take time to separate leaves from the stems hence may be inappropriate for the urban busy consumers. There is limited information on these aspects and more research needs to be done

f) Jute mallow

Harvesting: Harvesting technique depends on the production system (mono or mixed cropping). Generally, for the monocropping system, farmers harvest by uprooting the whole plant about 30-40 days after transplantation. In the mixed cropping system, they cut stems and leaves weekly about 15 cm from the ground. This technique allows new side shoots to develop. At the research station, jute mallow is harvested by cutting frequently.

g) Pumpkin Leaves

Harvesting. The leaves of pumpkin are highly perishable. When grown for sale at local markets, leaves are tied in bundles and these are kept moist until sold. Leaves are sometimes stored and marketed in dried form. To dry the leaves, they are chopped into small pieces and spread in the sun for 2-3 days depending on weather conditions. Dried leaves are stored in containers and are either marketed in some communities or used during the dry season. For fruits, pumpkins should be harvested after the skin has hardened and cannot be penetrated with a fingernail**.** Pumpkin fruits are still physiologically alive even after they have matured and are removed from the vine. They need to be cured before storage. The objective of curing and storage is to prolong the postharvest life of the fruit. Mature fruit store better than immature fruit. When mature, pumpkins have hard skins that resist puncture with your thumbnail. Skins of mature fruits appear dull and dry compared to the fresh, bright sheen of the skin of immature fruit. Leave a long stem (handle) on pumpkins. On squashes, the stems are removed completely. To lessen confusion, dead vines do not indicate maturity in pumpkin and squash. When vines die prematurely from disease or drought, for example, the fruits are likely immature and will not store for long. Curing involves elevating storage temperatures to 24-30°C with 75-80% relative humidity for about 5-10 days. Curing heals wounds, helps ripen immature fruits, enhances color, and ensures a longer post-harvest life. After curing, the temperature and relative humidity should be reduced to 10-13°C and 50-75%, respectively. Pumpkin and squash are chilling sensitive and should not be stored below 10°C.

h) Vegetable soybean

Harvesting. Vegetable soybean can be harvested when 80% of the pods are green, tender, and plump (8-10 mm in thickness) (about 35-45 days after flowering). It may take 65 to 75 days after germination for vegetable soybeans to be ready for harvest depending upon variety, temperature and weather conditions. The pods are stripped from the plants by hand.
Vegetable soybean is cholesterol free and has no saturated fats. It is rich in protein, vitamins A and B, iron, calcium and dietary fiber. Pods can be quickly refrigerated after harvesting to preserve freshness. The pods can be boiled and the beans eaten directly from the whole pod (pods are not edible). Or, remove the beans from the pods and serve in salads, soups, stews, or stir-fries. The beans easily pop out of the pods after cooking.

Module 5: Farm record keeping

Overview:
Record keeping facilitate seasonal evaluation and pre-planning activities for future seasons. Most farmers do not keep records and renders it difficult for researchers to also assess current practices for improvements. Along with other trainings, farmers are insisted on the importance of record keeping and this start in every demonstration plots in which traceability of all inputs used such as name, date of application and quantities applied are recorded, date of harvesting and quantities harvested as well as the farm gate value at the time of harvest.

Duration:
Throughout crop growth stages

Training materials:
Farm record book

The record keeping training follows mainly the following objectives:

- Quantify input costs to identify possible cost driver
- Quantify yields/ yield records
- Calculate profits considering the recorded costs and the yields sold to identify the most profitable vegetable crops (and varieties)
- Determine a more profitable input use
- Provide input cost data and yield data for the project M&E system

The record book has two main sections; the production record section and marketing record section whereby farmers can easily record all necessary activities and their costs in the given columns and rows.

a) Production Records
This contains information of production activities and costs to enable the farmer to see how much he/she spends on vegetable production per unit area:

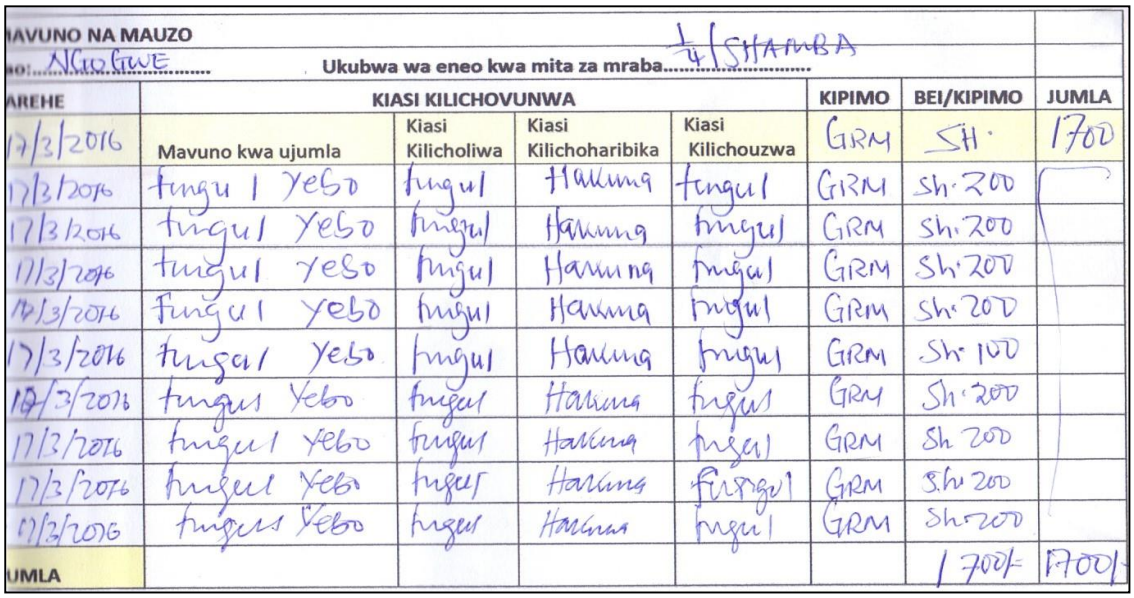
- land size,
- sowing and transplanting dates,
- land rent and preparation costs,
- input cost and application rates,
- labor costs,
- weeding, pesticides and fertilizer application costs, and
- Irrigation and harvesting costs.

b) Marketing Records
This includes all necessary marketing information on how much, where, when products have been sold:

- amount harvested per unit area,
- amount consumed at home,
- amount sold on the market,
- price per unit,
- transport cost if applicable
- amount wasted after harvest

Reviewing results
Existing records and practices shall be examined critically by the farmer in order to improve the overall production of the farm.

Farmers should consider record keeping as an important tool for overall vegetable production planning and marketing throughout the year.



MAVUNO NA MAUZO

Ukubwa wa eneo kwa mita za mraba 1/4 SHAMBA

AREHE	KIASI KILICHOVUNWA				KIPIMO	BEI/KIPIMO	JUMLA
	Mavuno kwa ujumla	Kiasi Kilicholiwa	Kiasi Kilichoharibika	Kiasi Kilichouzwa			
17/3/2016					GRM	SH.	1700
17/3/2016	fungu 1 yeso	fungu	Hakuna	fungu	GRM	Sh. 200	
17/3/2016	fungu yeso	fungu	Hakuna	fungu	GRM	Sh. 200	
17/3/2016	fungu yeso	fungu	Hakuna	fungu	GRM	Sh. 200	
17/3/2016	fungu yeso	fungu	Hakuna	fungu	GRM	Sh. 200	
17/3/2016	fungu yeso	fungu	Hakuna	fungu	GRM	Sh. 100	
17/3/2016	fungu yeso	fungu	Hakuna	fungu	GRM	Sh. 200	
17/3/2016	fungu yeso	fungu	Hakuna	fungu	GRM	Sh 200	
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17/3/2016	fungu yeso	fungu	Hakuna	fungu	GRM	Sh 200	
UMLA						1700/=	1700/=

Figure 4: Example of filled marketing section done by a farmer